October 2016

# Preventing Bird Strikes at Tocumen International Airport: An Approach through an Improved Waste Management System

Constantina Eleni Drakontis
*Worcester Polytechnic Institute*

John P. Ramos
*Worcester Polytechnic Institute*

Joshua J. Moniz
*Worcester Polytechnic Institute*

Tristan B. Cano
*Worcester Polytechnic Institute*

# Preventing Bird Strikes at Tocumen International Airport

## An Approach through an Improved Waste Management System


By:
Tristan Cano
Constantina (Ntina) Drakontis
Joshua Moniz
John Peter (JP) Ramos

WPI

Copa Airlines

# Preventing Bird Strikes at Tocumen International Airport
## An Approach through an Improved Waste Management System

An Interactive Qualifying Project Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
In Partial Fulfillment of the Requirements for the
Degree of Bachelor of Science
on October 15, 2016

Submitted By:
Tristan Cano
Constantina (Ntina) Drakontis
Joshua Moniz
John Peter (JP) Ramos

Submitted to:
WPI Advisors: James Chiarelli, Fred Hart, & Alex Sphar
Sponsor: Copa Airlines
Prof. Tahar El-Korchi, WPI


WPI

Copa Airlines

# Abstract

The large amount of refuse deposited in the vicinity of Tocumen International Airport attracts birds to the areas near the runways. Bird strikes pose safety hazards, cause delays, and damage equipment, deeming them a major concern for Copa Airlines and aviation as a whole. Observations of everyday airport and community activity were made, and interviews were conducted with stakeholders. Findings included, but were not limited to, the mishandling of waste in both the community and the airport. Based on the findings, recommendations were developed in order to improve the waste management system in the community, as well as the airport.

# Acknowledgments

The completion and success of our project were not only subject to our individual work and efforts, but were also dependent on the significant contribution of numerous individuals who we would like to thank.

First of all we would like to thank our sponsor, Copa Airlines, for making this project possible. In particular, Carol Domínguez Vergara for her continuous input and support. She was able to guide us throughout the entire process and her expertise on the subject and contacts were found to be very valuable both in the process of shaping our project, but also while developing recommendations to the problem. We would also like to thank Jaime Arosemena for his constant support in the field and willingness to help. We would not have been able to interview all of the residents if it were not for his help in introducing us and helping us communicate and translate.

Next, the development of our project would not have been the same without the help of people who willingly took time out of their schedules to talk with us and provide us with information that we needed. More specifically, Jorge Lizarraga joined us on our visits to the airport, making us familiar with the problem and the surroundings. We also conducted meetings with Melissa Heinz, Melissa Arauz, Isaac Escobar, and Michael Pacheco. Each of whom gave us important information relevant to the project. Finally, we would like to thank all the residents of the Tocumen community who took part in our brief interviews and supplied us with meaningful information that shaped our knowledge and later on established the base of our conclusions and recommendations.

Finally, this project would not have been possible without the guidance and counsel of our instructors and supervisors both before and during our time in Panama. Firstly, we would like to thank Professors Alex Sphar and Fred Hart for their instruction and contribution during our preparatory course (ID 2050) in

March-May 2016. We would also like to thank Professor James Chiarelli for his advice on our project and continuous encouragement while in Panama. We would like to acknowledge the Panama Project Center directors, Professors Aaron Sakulich and Tahar El-Korchi, for without their contribution, we would not be able to take part in this project. Finally, we would like to thank students Eric Cheng, Thomas Hlavenka, and Kyla Nichols, whose previous IQP suggestions contributed to the base of our project.

# Executive Summary

Bird strikes are a major and frequently problem at airports. In the year 2000, a study estimated the cost of bird strike damage and delays to be $1.2 billion USD per year (Allan). Not only do bird strikes pose a massive financial risk to airline companies, they also cause passenger safety issues. A recent example is in 2009 when multiple bird strikes caused US Airways Flight 1549 to lose its engines, and the pilot had to make an emergency crash landing in the Hudson River (National Transportation Safety Board, 2010). Even though there were no fatalities in this crash thanks to the expert landing by the pilot, from 1988 to 2013, 255 people were killed and 243 aircraft were destroyed because of bird strikes (Dolbeer, 2014).

Although Panama's Tocumen International Airport has attempted to prevent bird strikes through various types of deterrents, the problem has persisted over the last several years (Domínguez, 2016). A major reason behind the bird strikes is the waste buildup near the runways of the airport, specifically within the communities surrounding the airport as well as within the airport itself (Cheng, 2015). The waste management systems currently in place are inadequate and inconsistent, resulting in the continued attraction of birds to the areas surrounding the runways. This inefficiency has been, and will continue to be, exacerbated by the rapid population growth and urbanization of Panama City, specifically the community in Tocumen.

Copa Airlines recognizes that the waste buildup in the Tocumen communities is one of the main attractants to the birds which have been causing the bird strikes (Domínguez, 2016). With a new second terminal under construction currently, the waste management problem within the airport seems to be evolving, and is expected to become even more serious when the terminal starts operating (Lizarraga, 2016). Dissatisfaction and lack of communication between the waste management company in charge of collecting the waste in Tocumen and the residents were found to be the main obstacles preventing an

efficient waste management system up to this point. This project focused on confirming the waste buildup as one of the causes of bird strikes as well as investigating the potential shortcomings of the current waste management system of the Tocumen community and the airport itself.

## OBJECTIVES

The overall goal of this project is to prevent bird strikes from occurring at Tocumen International Airport in Panama through recommendations for improvements the waste management plan for the airport itself as well as for the surrounding community. In order to achieve this goal, the following objectives have been defined:

1. Assess the state of waste management in Tocumen community, as well as in the airport.
2. Identify the types of waste and causes of buildup, then attribute factors to the current waste situation.
3. Evaluate the level of knowledge about the waste situation among the stakeholders.
4. Determine the level of concern among categories of stakeholders.
5. Recommend improvements for the waste management plan in the Tocumen community and the airport.

## METHODOLOGY

A methodology was developed to achieve the project's objectives and overall goals. An overview of that methodology is as follows:

On-site visitations of the Tocumen community were one of the most significant tasks on our project. We were able to assess the state of waste management situation in the community, identify the types of waste and causes of buildup, noting the factors contributing to the current state of the refuse problem. We

focused on on-site visitations of the community and conducting short interviews with multiple residents. Questions were asked in order to obtain the reason for the buildup of refuse according to the community members. Observations made and data collected during the visitations were recorded and then further analyzed in order to fulfill the goals of the project. These short interviews made it possible to evaluate the level of knowledge about the waste situation among the residents and gather an overall idea of the community's opinion on the waste management system in place.

Accordingly, to have a clear and better understanding of the refuse situation in the airport itself, we visited the airport land and interviewed staff from Tocumen International Airport and Copa Airlines. Through visitations of the areas that are most affected by the waste problem, the situation at hand was better observed and evaluated. The interviewees included, but were not limited to, operational managers, the Copa ground safety manager, the Copa ground safety investigator, and the Tocumen public relations manager. Through correspondence with the sponsor, the level of concern for the bird strikes was determined. Also, by examining bird strike data collected by the company, the desired effort to mitigate bird strikes can be examined. However, Copa Airlines is not the only airline operating at Tocumen International Airport. Interviews were conducted with staff of the airport in order to determine the level of concern at the airport about bird strikes. In addition to Copa, other airlines operating at the airport are affected by bird strikes, and they may support suggested improvements to the waste management systems proposed by this report.

In addition, research on best waste management practices from similar cases was also done, in order to find successful previous practices that could potentially be applicable in our situation.

A community education program which is established by a waste management authority, Autoridad de Aseo, was observed and the leaders of the program were interviewed in order to evaluate possible

improvements to the program. Depending upon the interview results, the community education program can be improved and extended. Possible improvements include suggestions for better waste disposal habits, and possibly improving the relations between the municipality and the community. Suggestions on specific waste management improvements were made after obtaining data and information based upon several factors, including, but not limited to, the types of waste present, the results from the conducted interviews, the extent of the success of the waste management company, and the successes of different strategies in similar situations worldwide.

Finally, the recommendations and findings of our project were presented to Copa Airlines and the administration of Tocumen International Airport. They have the ability to implement the developed recommendations to the waste management systems both in the airport itself but also cooperate with the Tocumen community.

# FINDINGS

**Concerning the community at Tocumen:**

1) *The existing waste collection system present in the Tocumen community was determined to be inconsistent, leading to confusion amongst the residents concerning what the waste collection system truly accomplishes.* Ninety-five percent of our interviewees claimed that they are not comfortable or content with the amount of waste in the streets. However, when the residents were asked what days the waste collection trucks come through, answers varied from once a day to once a month. This indicates that the waste collection system present is inconsistent and, most importantly, that residents are not properly informed about the exact schedule, if one does exist. Even the residents who indicated weekly or biweekly pickup of waste from the trucks were unable to indicate on which specific days this occurred.

2) *The methods of disposal of waste varied throughout the interviewed residents, and included both proper and improper handling of waste.* During the on-site visitations conducted at the community, numerous residents were witnessed dumping their waste on the side of the roads. On the question concerning waste disposal, fifty-five percent of the interviewees indicated improper waste disposal, i.e., confirming that they had left waste by the roadside. The other forty-five percent of answers included door to door pickup, placing in a dumpster, using a private waste management company, and waiting for a truck to come by.

3) *Due to a large percentage of residents mishandling waste, a large amount of refuse was witnessed along the roadways.* Approximately 7,500 families in the Tocumen community leave their waste in the streets. Hence, there are numerous clusters of waste throughout the community. From the on-site visitations it was determined that even though a great amount of the waste was bagged, it was not always properly closed and many times simply dumped uncovered. This attracts scavenging animals, which then attracts larger birds, and this also makes waste collection very challenging for the workers. This results in a large amount of waste being left behind even after the truck has collected the majority of bags.

4) *A recent implementation of a youth community education program concerning waste management at a local school could serve as a starting point for long-term cultural change in the community.* The program is run by Autoridad de Aseo, a government agency, and has been implemented since May 2016, running once a week for 6 months. It is directed towards children aged 9-10 years old and its aim is to educate a group of about

25 selected kids from different classrooms about waste management, in the hopes of those kids passing their knowledge to their friends and families. Children were excited about the program and took part in all activities, showing optimism about the next generation.

**Concerning the airport itself:**

1) *International waste is collected twice daily by Servicios Tecnológicos de Incineratión (STI), totaling approximately 300,000 kg of monthly waste as shown in Appendix B.* The waste collection process removes approximately six tons of waste every day, with approximately 350 waste bags removed in the morning collection process, and about 270 waste bags in the evening process.

2) *While waste from international flights arriving at Tocumen is currently transported to a waste incineration facility in Colón, a future plan is in progress to build a waste incineration facility on-site near the cargo terminal.* Due to mandatory regulations, all international waste must be incinerated. After the waste is collected at the airport, the truck travels about fifty miles to the incineration facility, situated in Colón. The distance is long enough to allow the waste from incoming flights to fill up the bins, and sometimes even overflow. This is why the airport operations staff has begun plans to build an on-site incineration facility at the airport. With the new terminal on the way, there will be an additional twenty-two waste pickup locations. By building an on-site waste incineration facility, waste could be collected multiple times each day at all four terminals.

3) *Insufficient bin coverage and bin capacity were noted at the various ramp and gate locations at the terminal.* During the on-site visitations, several overflowing bins were witnessed. Bins were also often uncovered, attracting birds to the area. At the same time, many bins were empty or unfilled. This shows lack of ability to manage the waste of the incoming flights, which is something that could easily be fixed.

4) *Low quality waste collection bags are transferred by hand by STI workers to a waste collection truck.* In an interview with the Cabin Services Manager for Copa Airlines, he specified that the thickness of the waste bags was 0.8 mil, or 0.02 mm, which is the lowest allowed by regulations. While witnessing the waste collection process at the airport, several waste bags were observed to be torn or punctured, with refuse spilling out. Sometimes, the waste collection workers would not notice, and the loose refuse would be left behind.

5) *Loose refuse in ramp areas attracts birds, despite the current bird deterrents in place.* In addition to the waste that spills out of the ripped waste bags, a noted contributor to the loose refuse problem is the workers themselves. Small birds are attracted to the waste on the ramps that is easily accessible. While walking through the airport ramps, a bird was photographed with a worker's food waste in its mouth. Even though the airport and Copa have attempted to take measures in order to scare the birds away by implementing sound deterrents, the birds can easily become accustomed to the sounds.

# RECOMMENDATIONS

**For the Tocumen Community Representatives:**

1) *Establish designated waste disposal locations.* This will encourage a large majority of residents to only dispose of their waste in these specified areas and loose waste near the main street streets and bus stops will decrease.

2) *Establish a fixed waste collection schedule with Autoridad de Aseo.* A set schedule clearly communicated between the community and the waste authority (Autoridad de Aseo) will allow for the community to collaborate with the waste collection workers on collection days so that no stray refuse is left behind.

3) *Work with Autoridad de Aseo to improve waste collection efficiency.* Often a truck will fill completely before completing its collection route leaving refuse behind and allowing leftover waste to accumulate over time, indicating that the waste collection is not efficient. An increased capacity is needed and could come in the form of added trucks or also be accounted for by an increased collection frequency in the area.

4) *Work with Autoridad de Aseo to obtain more waste collection bins.* Receptacles for waste were a rarity. Public dumpsters should be stationed at specified points for residents to dispose of their waste, providing a place to put refuse, but also preventing a large amount of animals from feeding on the waste.

5) *Expand community education program on waste management.* The current community education program established by Autoridad de Aseo is a significant step forward to

improving the way that residents view waste. This program is well received by the children involved as stated previously, and should be expanded to involve more children.

6) *Establish a recycling program.* If the Autoridad de Aseo can encourage recycling and possibly establish a system for residents to recycle plastic in exchange for a reasonable price, it would help the waste situation. An established recycling program not only reduces the impact on the environment, but can be a relatively inexpensive way to remove waste from the cities and surrounding areas.

**For Tocumen International Airport and Copa Airlines:**

1) *Provide larger or more adequate amounts of waste collection bins in ramp areas.* By increasing the capacity that the total number of bins can handle during the periods between collections, there can some alleviation to the loose waste issue.

2) *Establish an employee education program emphasizing foreign object debris (FOD).* If employees are aware of the dangers associated with FOD, a higher level of concern among the workers in the ramp area will ensue.

3) *Provide higher quality waste collection bags to limit tearing.* Although the waste collection bags for international waste comply with regulations, they do so with the smallest allowable thickness, roughly 0.8 mil, or 0.02 mm **(**Escobar, 2016). The thickness of the bags may also leave them susceptible to puncture by birds or other wildlife.

4) *Limit transfer of waste by hand within the airport.* Utilization of trucks equipped to lift and empty dumpsters can increase efficiency of the waste removal process. It will also

reduce the amount of stray and loose waste that is dispersed during the waste transfer process.

5) *Ensure waste collection bins are covered when not in use.* As with every type of waste receptacle, failing to place a cover over the waste leaves the bags inside vulnerable to puncturing via wildlife or other outside factors. In order to prevent this potential attraction, it is recommended that the waste collection bins on the ramps remain closed when not in use by staff.

6) *Proceed with plan to build an on-site incineration facility.* It is highly recommended that the on-site incineration facility on airport grounds be completed as quickly as possible in order to both help solve the loose waste issue and facilitate the introduction of other methods of waste reduction at the airport.

# Authorship

| Section | Primary Author | Primary Editor |
|---|---|---|
| Abstract | JP | All |
| Acknowledgments | Ntina | All |
| Executive Summary | Ntina | All |
| Introduction | Tristan | All |
| Background | All | All |
| Methodology | JP | All |
| Findings | Joshua | All |
| Conclusions and Recommendations | JP & Tristan | All |
| Appendices | All | All |

# Table of Contents


ABSTRACT i
ACKNOWLEDGMENTS ii
EXECUTIVE SUMMARY iv
AUTHORSHIP xiv
TABLE OF CONTENTS xv
TABLE OF FIGURES xvi
ACRONYMS xvii
INTRODUCTION 1
BACKGROUND 3
1) Advancement at Tocumen International Airport 3
2) Bird Strike and Airport Relationships 4
3) Waste Management Systems Implemented in the World 9
4) Issues in Waste Management 12
5) Current Situation in Proximity to Panama's Tocumen International Airport 17
METHODOLOGY 24
Objective 1 25
Objective 2 27
Objective 3 28
Objective 4 29
Objective 5 30
FINDINGS 31
For the Tocumen Community 31
For the Airport 40
CONCLUSIONS & RECOMMENDATIONS 46
For the Tocumen Community 46
For the Airport 49
REFERENCES 53
APPENDIX A: INTERVIEW QUESTIONS 56
APPENDIX B: STI DATA SHEET 59
APPENDIX C: SPONSOR DESCRIPTION 60

# Table of Figures


| *Figure Description* | *Page* |
|---|---|
| Figure 1: Construction of the new terminal at Tocumen International Airport | 4 |
| Figure 2: Bird Migratory Routes through North and South America | 18 |
| Figure 3: Fall Migratory Routes in Panama | 19 |
| Figure 4: Layout of Tocumen International Airport | 21 |
| Figure 5: Frequency of waste collection according to residents of the community | 32 |
| Figure 6: Small birds scavenging amongst the waste | 33 |
| Figure 7: Waste roadside | 33 |
| Figure 8: Waste roadside | 33 |
| Figure 9: Methods of waste disposal for the Tocumen Community | 34 |
| Figure 10: Resident using a wheelbarrow to dump non-bagged, uncovered waste | 37 |
| Figure 11: The morning after waste collection | 37 |
| Figure 12: Students taking part in activities during the education program | 39 |
| Figure 13: Plastic waste, mostly bottles, on a local beach in Panama City | 39 |
| Figure 14: Waste collection at the main terminal around 8:30 am | 40 |
| Figure 15: Overflowing, uncovered waste bin at the airport | 42 |
| Figure 16: Refuse unnoticed and left behind by waste collection workers | 43 |
| Figure 17: Bird with a worker's food waste in its beak | 44 |
| Figure 18: Uncovered receptacles for FOD | 45 |

# Acronyms

COPA - Compañía Panameña de Aviación
FAA - Federal Aviation Administration
FOD - Foreign Object Debris
IQP - Interactive Qualifying Project
PTY - Tocumen International Airport
STI - Servicios Tecnológicos de Incineración
US - United States
USDA - United States Department of Agriculture

# Introduction

Every airline desires flights to be efficient and to avoid interruptions. One of the major problems that may arise at airports are bird strikes, which damage planes, cause delays, and pose safety concerns. In the year 2000, one study conservatively estimated the cost of bird strike damage and delays to be $1.2 billion USD per year (Allan). With an increase of about 40,000 aircraft worldwide since 2000 (Aeroweb, 2014), the amount of monetary damages to this date have surely increased. Not only do bird strikes create a massive financial risk to airline companies, but they also cause passenger safety issues. From 1988 to 2013, 255 people were killed and 243 aircraft were destroyed because of bird strikes (Dolbeer, 2014). One specific example of a bird strike occurrence was during 2009 when multiple bird strikes caused US Airways Flight 1549 to lose its engines, and the pilot had to make an emergency crash landing in the Hudson River (National Transportation Safety Board, 2010). Luckily, there were no fatalities as a result of the crash dubbing the "Miracle on the Hudson." Bird strikes do occur and can be lethal.

Despite employing preventative measures to avoid bird strikes, Panama's Tocumen International Airport has experienced numerous bird strikes over the last several years. These collisions frequently take place near the runways. A major cause of bird strikes is the buildup of waste in close proximity to the runways, specifically in the community surrounding the airport, as well as within the airport itself. The waste management systems currently in place are inadequate and are the major reason for the waste buildups that occur and attract birds to their locations. This inefficiency has been, and will continue to be, exacerbated by the rapid population growth and urbanization of Panama, which is a rapidly developing country and has one of the fastest growing economies in Latin America (Central Intelligence Agency, 2016). If left unchecked, bird strikes could become an even larger problem in the area.

The local community of Tocumen near the airport lacks a consistent waste management program. Copa Airlines recognizes that the waste buildup in the area is an attractant to the birds that have been causing

the bird strikes. This project focused on confirming the waste buildup as one of the causes of bird strikes, as well as investigating the potential shortcomings of the current waste management system of the Tocumen community. In order to recommend solutions to this issue, interviews of community members, as well as airport and airline employees, were conducted. Data on bird strikes and the current waste management system were collected as well. The project suggests possible solutions to the bird strike problem through collaboration of the community, government, airlines, and airport.

Through on site visitation and observation of the waste management process, the state of waste management in Panama was assessed and the sources of the buildup of refuse and the types of waste were identified. Through interviews with staff and employees of both Copa Airlines and Tocumen International Airport, this project determined the amount of concern attributed to different stakeholders for the problem and their willingness to alleviate it. Through interviews with the residents, their level of knowledge about the waste buildup was assessed, and a sense of the cooperation for resolving this issue was obtained. Finally, the data collected was analyzed in order to develop recommendations for improving the current waste management system in the Tocumen community area, as well as for the airport itself. These recommendations will theoretically aid the effort to decrease the frequency of bird strikes occurring at Tocumen International Airport.

# Background

## 1) Advancement at Tocumen International Airport

Tocumen International Airport (PTY), Panama, is the busiest airport in not just the entire country, but in all of Central America. As Panama undergoes rapid development, the airport is also expanding at a fast pace. PTY, commonly referred to as the "Hub of the Americas," serves as the home base of what Kasarda described as, "...one of the world's fastest growing and most successful airlines, Copa, whose aircraft widely connect Panama to North, South, and Central America as well as the Caribbean" (Kasarda, 2011). In order to keep up with the ever-increasing demand for flights, PTY has undergone several expansions, some still ongoing to this day. A recent addition to the airport that finished construction in 2011 added a new north passenger terminal and with it 12 new gates, which at the time brought its total up to forty (Kasarda, 2011). Tocumen's ambition does not end there, however. Construction on a new, state-of-the-art south terminal, dubbed "Terminal 2" or T2 for short, is already underway and is slated for completion by 2017 (Tocumen International Airport, 2016). There are also plans for a new parallel runway to be constructed between 2022 and 2024 to help alleviate its already congested runways and, if finances hold up, to build a monorail link to a rail station two kilometers away (Bates, 2015). These renovations are all part of a larger effort towards constructing an airport city around Tocumen, what would be the first in all of Central America. Office buildings, hotels, and meeting facilities are being proposed to anchor the airport city along with retail and consumer services that will complement those in Tocumen's passenger terminals (Kasarda, 2011).

Figure 1: Construction of the new terminal at Tocumen International Airport (Gohel, 2014).

As one can imagine, Tocumen's functionality is crucial for the economic well-being of a country undergoing such rapid development. Unfortunately, with such a large airport come numerous difficulties in operating at top efficiency. One of the major problems and the focus of the project is the occurrence of bird collisions with aircraft, known as bird strikes.

## 2) Bird Strike and Airport Relationships

### 2.1 Bird Strikes as a concern:

In-air collisions of birds with aircraft pose a threat to the aviation industry, passenger safety and wildlife. Various techniques exist to control the bird strikes, but whether or not they are in use and the extent of implementation and application of these techniques to each airport varies widely. Often, the variation exists as a result of the level of risk to bird strikes associated with each situation. For example, if an airport is surrounded by big cities and tall buildings, it is less likely that birds will be posing a great threat. However, if the airport is surrounded by rural communities which are welcoming to birds, bird strikes are almost inevitable. Thus, airports are more likely to invest in stopping bird strikes if they are greatly impacted. For those airports which are affected,

inability or unwillingness to invest in bird strike deterrents usually stems from a lack of knowledge of the true cost of bird strikes (Cleary, 2000). This cost comes in the forms of both physical damages to the aircraft, as well as delays and cancellations. The measurable repair costs of physical damage are often focused, however, the costs presented after a delayed or even canceled flight can be as valuable.

Another problem arising in many situations is the perception of this issue from the airport and the airlines. If the average number of bird strikes occurring at an airport is higher for a specific runway, it means that probably the area surrounding that runway is particularly welcoming to birds for different reasons. However, the airport decides which area of the airport is occupied by which airline. This is a problem present in a system where one commercial company (the airport) would be spending money to allow another company (the airlines) to save money (Allan, 2000).

## 2.2 Solutions:

There is an array of methods that can be used to prevent birds from colliding with aircraft. However, because the surrounding geography and location of each airport varies greatly, the airport authorities themselves decide on what would be more effective for each case. Among the various factors that must be taken into consideration when deciding upon the aforementioned countermeasures is the ecological impact of each method. The goal should be eliminating bird attractants and not the birds themselves. Some of the most common techniques include scaring birds away using deterrents, making the surrounding communities and environment less appealing to birds, and predicting the movement of birds.

*Overhead Nets:* The use of netting was found to be particularly successful at José Joaquín de Olmedo International Airport in Guayaquil, Ecuador, and seems promising for any area near

wetlands (Cheng, 2015). Overhead grid line systems are placed approximately 5 feet above the ground, preventing large aquatic birds from flying lower than this barrier and landing in the wetland areas close to the airport. The length of the grids of wire is large enough to cover a sizable area around the airport. The construction is feasible and less expensive than other possible methods, while simultaneously avoiding serious damage to the surrounding environment. These nets could prove useful if implemented at Tocumen International Airport, however it would only partially solve the bird strike issue, as there are other factors that attract the birds to the areas surrounding the airport.

*Audio and Visual Bird deterrents:* Deterrents are one of the most commonly used methods of prevention by airports, as they are very inexpensive and easily attainable. Pyrotechnics, noise guns, and lasers are used to instantly remove birds from airports by frightening the animals away from the area. However, these measures are only meant to be a temporary solution. Through repeated use, the birds eventually become accustomed to the sounds and visuals, making these methods ineffectual for long-term use (DeFusco, 2013).

*Live-Ammunition Shooting:* Even though both the Federal Aviation Administration (FAA) and the United States Department of Agriculture (USDA) support live-ammunition shooting as an "effective practice" for wildlife population reduction, it is highly restricted and should only be used when all other prevention methods have failed or in specific cases when immediate removal is necessary (Cleary and Dolbeer 2005). The loud noise can frighten away the birds, and in the event of the death of one or more of the flock members it is more likely that the rest will immediately disperse. While this does often lead to the permanent removal of the target birds in a given area, it does not, however, address the underlying cause of the bird attraction, thus allowing for a potential resettling of the area by a new flock. Much akin to the deterrents, the long-term

efficacy of this method is questionable at best. The killing of birds may also raise ethical issues, and could potentially be perceived in a negative light by some.

*Landscape and Waste Management:* Landscape alteration and a functional waste management system are methods that provide a long-term solution to the problem of bird attraction and, as a result, help to lower the instances of bird strikes. Most airports are located either on the outskirts of their respective city's limits or completely separate, and often somewhat rural, areas for safety and financial reasons. There is a lack of urban surroundings around the airports whose place is often taken by wetlands or other natural topography. In addition, there is the potential for any waste buildup in the area due to a dysfunctional waste management system or the presence of a landfill. These two factors combine to create an appealing location for wildlife, most notably birds. As the number of birds that flock to these areas in close proximity to the airports increases, the instances of bird strikes will also increase. In places such as Tocumen International Airport where the solid waste management system in the surrounding communities may not be functioning properly, as well as the abundance of wetlands, mangroves, and rivers on airport grounds and the surrounding areas, creating functional landscape and waste management systems would be an effective solution to the bird strike issue. However, these methods would require the cooperation of the airport, government, Tocumen community representatives, and owners of private land in the surrounding communities.

The previous Interactive Qualifying Project (IQP) team working with Copa Airlines on bird strike prevention found that excessive waste buildup in the surrounding areas of Tocumen International Airport in Panama is one of the major attractants of birds to the airport (Cheng, 2015). The waste management system in the area and the country in general, seem to have many flaws. Schedules are not followed strictly, and frequently waste in areas outside major cities does not get picked up

for extended periods of time. This can result in overflowing collection bins and open dumping of waste by the residents in non-residential pieces of land, which happen to be close to the airport. This of course attracts birds and increases the potential for bird collision danger. In order to decrease the collisions, we believe it may be easier and cheaper to eliminate a source of the problem which will help in the long run, rather than constantly be implementing short term, ineffectual solutions. As a result, we will primarily be working with Copa Airlines and the surrounding communities in order to formulate a sustainable waste management system, as well as potentially pursuing additional bird strike prevention methods.

**2.3 Effect of Waste on Bird Attraction:**

As previously stated, the waste in the adjacent community was found by the previous team to be a major contributor in the occurrence of bird strikes at the airport. In addition to the waste that is left haphazardly on the streets in the Tocumen community, there are also cattle farms and slaughterhouses nearby that also leave scraps and other refuse outside as well (Cheng, 2015). Black vultures, which were found to be the culprit in a majority of the reported bird strikes at Tocumen International Airport, feed heavily on carrion and other food scraps in areas where agriculture is present, making these areas extremely attractive and a perfect place to live for these birds (Kelly, 2007). With the community situated north of the northern runway where most takeoffs at the airport occur, it is easy to imagine how birds flocking to these areas in search of food would pose a threat to the aircraft attempting to take flight. Improving the waste problem would reduce a major source of attraction for these birds, theoretically reducing the instances of bird strikes. In order to accomplish this goal, however, a closer look must be taken at the handling of other waste management problems similar to the one in Panama to learn from their findings, and adapt them to the situation at Tocumen.

# 3) Waste Management Systems Implemented in the World

The following section will focus on instances of waste management systems that have been implemented in recent years in varying locations. Certain waste management systems were referenced based on their applicability to the project. This was based upon methodology or execution that could be utilized and implemented to a certain degree in the project areas within Panama.

## 3.1 Case Study of Developing Urban Areas in South Africa:

Korfmacher describes the developing urban areas in South Africa, specifically their difficulties in implementing a sustainable waste management system. This case study of Klippan in South Africa utilized interviews, household surveys, and also a waste stream composition study taken in 1993 in order to design a waste management system for the region (Korfmacher, 1997). The methodology used is highly applicable to the current situation in Panama. Interviews can introduce concerns of community members that other data may not. The surveys and interviews were able to show that residents were highly dissatisfied with their collection service and it was discovered that, due to inefficient collection of waste, the local landfill was highly underutilized (Korfmacher, 1997).

Solutions were proposed based on the varying socioeconomic factors of the residents of Klippan as well as the geography of the isolated area. Korfmacher notes how first-world waste compactors are not financially feasible in this region due to high maintenance costs as well as poor road conditions. Waste reduction techniques such as composting and recycling were highly encouraged to minimize waste transportation costs. A recycling system was also suggested based on its ability to generate income as a motivational incentive. Finally, a house-to-house or block

system was suggested as a labor intensive collection system, and residents expressed a willingness to pay for a collection service. A small collection vehicle (non-compactor) was more economically feasible for this region. The collector would exchange fees for collection bags, and this would in turn encourage the practice of waste reduction techniques such as composting (Korfmacher, 1997).

### 3.2 Recommendations to Improve Waste Management in Costa Rica:

A previous IQP performed by WPI students involved the evaluation of three waste management systems in three different municipalities in Costa Rica, as well as two cities in the United States (Samuels, 2003). Waste management techniques utilized by the two cities in the United States were considered by the group to be efficient and successful based on economic feasibility and environmental effectiveness. One of the United States' cities, Shrewsbury, was considered to exemplify "good U.S. practices." Utilizing waste production and management data as well as interviewing techniques, the group was able to learn about the programs and systems used by the municipalities (Samuels, 2003).

The selected Costa Rican municipalities for the project were seen to be highly inefficient in their respective waste management systems. Landfills were poorly regulated, and collection services were poorly organized compared to those of the United States. Waste management systems are not directly transferrable to different municipalities. However, there are certain successful practices that may be able to be implemented in another location. Based on successful practices seen in the United States, the group was able to suggest waste reduction techniques to improve those in Costa Rica. For example, they suggested expansion of the composting and recycling programs, two commonly utilized waste reduction techniques. Waste reduction is often

referenced in improving waste management techniques, and would significantly reduce the waste buildup in the municipalities including those in Panama (Samuels, 2003).

### 3.3 Community Collaboration of Waste Management in a Bangkok Slum:

Another project conducted by a group of students from WPI was tasked with a similar goal, this time instructed to design a waste management system for the Khlong Toei slum in Bangkok. Environmental and health hazards were the primary motivating factors in developing a sustainable waste management system for the area. This project emphasized working with the local residents to help improve their knowledge about waste reduction, and focused specifically on waste disposal habits (Aroonsri, 2014).

Organizations that have had success in suggesting waste management behavioral changes were interviewed by the group, and children were suggested as the group most readily open to behavioral changes regarding waste. Educational activities were recommended for the schools of the children to try to facilitate their behavioral change. Through interviews conducted within the local community, recycling certain waste items as a source of income was found to be a very appealing option to the residents, since they would directly benefit from it. Adults were further collaborated with through recommendations of community activities involving art (Aroonsri, 2014). The community collaboration portion of the project is highly applicable to the situation in Panama, since the potential for success of a program such as this is high.

### 3.5 Applicability to Panama:

Panama, like many developing countries, has a growing population. Panama City is growing and developing especially, including renovations to Tocumen International Airport as shown in this report. Waste management has been an issue in Panama City as described later in this report.

Through utilization of successful methodologies seen in previous instances, a waste management plan can be suggested to benefit the stakeholders involved in the scope of the project.

# 4) Issues in Waste Management

Difficulties in maintaining functional waste management systems are not isolated to the situation in Panama and as such have well-documented accounts throughout the world. The following section takes a closer look at case studies in China, Kenya, Thailand, and Panama and discusses the varying types of waste management problems that are commonly encountered in developing countries undergoing rapid development, as well as issues that are indigenous to their respective location, and the health and environmental risks associated with poor waste management systems.

## 4.1 Common Issues:

*Inefficient Waste Management Systems:* Perhaps the most recurring problem seen in the various case studies and projects performed that involved a dysfunctional waste management system is the inconsistency with which waste is removed from the afflicted areas. Often, the companies responsible for collecting the waste do not collect from each area, which results in an eventual overflow of waste. When waste is taken away and brought to landfills, it is often the case that these, too, do not partake in good practices (Zhang, 2009). There are a myriad of reasons for this neglect. It may be part of a larger political issue, such as an inflated number of workers for political authorities that causes a shortage in other services including waste management, which in turn leads to the inefficient collecting (Henry, 2006). In other cases areas under the service of a particular waste management provider are merely forgotten or looked over. The problem is then placed into said areas' own jurisdiction, where illegal burning and dumping is undertaken to relieve the issue (Linowes, 2006). Other areas are just difficult to access for these companies. In

addition to these problems, an underlying lack of knowledge of proper disposal methods can also be attributed to the overall issue.

*Lack of Public Awareness:* Compounding the issue of the systems in general is the potential for residents of the areas themselves to know or care little of the impact of the waste buildup and, in some cases, contribute to it as well. In places where waste buildup is an everyday part of life, the residents of these areas normally possess what Linowes describes as "a very casual attitude toward waste." For example, the typical urban Panamanian is accustomed to a daily pickup of waste (as opposed to a weekly collection that has become the norm in more developed countries, an idea found to be very odd by these people) provided by the city's waste authority, so littering is a common practice (Linowes, 2006). This pickup is viewed by the citizens as a right and an obligation from the government. Unfortunately, the waste authority lacks the proper funding from the government to provide adequate service to an ever-increasing population, resulting in the buildup of waste (Linowes. 2006). Scavengers that sift through the refuse in search of useable items can also lend to this trouble, often displacing the unwanted portion of the refuse into streets or alleyways, further increasing the affected area as well as posing health and environmental risks (Zhang, 2009). Incentives for cleaning up the waste and recycling it is also severely lacking in most of these countries.

*Rapid Population Growth and Urbanization:* One major common factor present in these case studies is the rapid urbanization and population growth being undergone by these "developing countries," a term used to describe those places with less-developed industrial bases, which the aforementioned countries would classify as. This can lead to large-scale waste management failure when there is a lack of resources to be able to provide for a sustainable waste management plan in order to support this rapid growth. The increasing population density can be especially

troublesome if waste management was already an issue to begin with, since it can severely exacerbate the original problem. In addition, it makes establishing landfills and other places to store the waste even harder to accomplish (Zhang, 2009). Panama falls under the umbrella term of a "developing country," however loosely, and is one of the more rapidly growing countries in Latin America in terms of urbanization.

**4.2 Unique Issues:**

*China:* Processing waste in cities in China can particularly difficult due to the overall lack of labeled receptacles for each type of waste (Zhang, 2009). It is not common practice to have this separation waste that most western countries implement. There is also trouble with the biogas recovery rate in Chinese landfills, a result of the degradation of organic matter in the landfills, which can pose serious environmental risks. The rate of western cities is around 60%, while China's falls below 20% (Raninger, 2009).

*Kenya:* Laws pertaining to waste management in Kenya are very rarely if at all enforced, which opens the door for unlawful business practices (Henry, 2006). The poor waste management also impacts the local economy. Tourism plays a big factor in Kenya's economy, so any degradation that happens to the environment can have a devastating impact on its fragile economy (Henry, 2006).

*Thailand:* The slums of Thailand are a rapidly growing section of the country with an ever-increasing population and very little money. As a result, the homes in these areas are often made of cheap, easily accessible materials in order to avoid poverty and risk of eviction, though these are not always the most hygienic living conditions (Aroonsri, 2014). The homes are also extremely flammable as well as in close proximity to one another, allowing fires to spread quickly throughout the settlements. The waste buildup around these makeshift living quarters

provides not a just health risks, but also the opportunity for a fire to spread even more quickly than it normally would.

**4.3 Environmental Risks:**

*Leachate Collection:* Waste buildup can often lead to the discharge of leachate, or liquid (usually water) that has dissolved environmentally harmful substances, into the environment. Landfills are meant to be equipped to filter this leachate out and return the sanitized water. However, these landfills are often ill-equipped to handle this task, lacking many of the basic infrastructures needed to carry out this task. This can be attributed to a multitude of reasons, including careless operation and maintenance of the leachate collection and treatment and inadequate emphasis during construction of pollution control systems (Zhang, 2009). Other landfills, such as the few present in Kenya, lack even the most basic liners used to filter the leachate (Henry, 2006). As a result, this unfiltered water can make its way back into larger bodies, causing numerous environmental health issues. Most of this leachate pollution goes unreported, making it an even greater threat to the environment.

*Incineration:* The use of incineration, while a useful waste management technique when performed under controlled conditions, is often undertaken illegally and without supervision by the locals of the areas impacted by waste buildup**.** Not only is there the potential for toxic emissions to enter the air, but there is also the generation of a considerable amount of solid residues (Zhang, 2009). This solid residue is also often disposed of improperly, usually by dumping it into rivers (Linowes, 2006).

**4.4 Residential Health Risks:**

*Scavenging:* Rummaging through waste for materials of monetary value is often a way of life for people living in these areas, but it can also present a serious risk to their health (Zhang, 2009). Infections and diseases can be contracted in the waste buildup, not to mention the general filth the waste exudes

*Animal Infestation:* Waste buildup has the tendency to attract various types of wildlife in search of a meal. These animals, particularly rodents, can carry with them deadly diseases that are easily transmittable as a result of the close proximity the animals share with the residents (Aroonsri, 2014). While not a direct health risk, the attraction of birds to the waste buildup, especially in Panama, can present a danger to aircraft taking off and landing at airports, which in turn endangers human lives.

*Water Pollution:* The leachate that enters bodies of water has an impact on the human populations near it as well. Drinking from and bathing in large bodies of water is a common practice in developing neighborhoods. When the leachate enters these bodies of water it poses an immediate threat to the health of nearby residents, as it is an easy way to contract diseases.

**4.5 Summary:**

In short, the major issues with waste management in countries similar to Panama can be distilled down to a few key points. First, the inefficiency of waste management systems currently in place remains the largest factor in the failings of these systems. Second, a lack of public awareness or care regarding the waste buildup issues compounds the damage started by the ineffectuality of the systems themselves. Finally, the existing issues are further exacerbated by the rapid population growth and urbanization occurring in these developing countries. These problems can have a

massive negative impact on the areas in proximity to their occurrence, posing a large threat to the health of the residents of the area as well as that of the surrounding environment. These potential threats make solving this issue of utmost importance.

# 5) Current Situation in Proximity to Panama's Tocumen International Airport

In order to improve the bird strike problem with as much success as possible, the context of the problem must be investigated. While bird strikes cause problems for airports worldwide, no two situations are the same. It cannot be assumed that the solution used at one airport to prevent bird strikes or to handle waste management will work again at Tocumen International Airport because of the differing contexts and variables these problems have, which must be taken into account. This section will describe the context of the problem in Panama, which will allow for informed decisions regarding bird prevention methods, as well as waste management solutions.

## 5.1 Bird Strike Information at Tocumen:

At Tocumen International Airport, there are a multitude of birds. Bird strikes occur at an average of ten times per month. While many of these bird strikes do not cause much damage, about one in five of these bird strikes will cause at least some minor damage to the airplanes. (Copa Airlines, 2015). In an attempt to expel the birds from the airport, the wildlife control team at the airport has employed both firecrackers and noise guns, but the deterrents have lost effect on the birds, as they have acclimated to the noise (Cheng, 2015). As a result, Copa Airlines would like to focus on other possible methods for removing the birds permanently.

There are indeed more than one species of bird causing the bird strikes at the airport. However, as previously mentioned, the prevalent species of bird appears to be the black vulture (Cheng, 2015). These black vultures nest in areas that are wooded, and search for their food by flying high up over spacious, open areas. (Cornell, 2015). Black vultures move around by riding thermals, upward hot air currents that allow birds to glide around and gain height with ease. (Smithsonian Tropical Research Institute, 2014).

According to the previous IQP group, an airport inspector remarked that, "The airport is a five star hotel for birds". A variety of factors attract the birds to Tocumen International Airport, including the bird migration patterns, existence of thermals at the airport, and the surrounding geography (Cheng, 2015). A major bird migratory route, the Trans-American flyway, crosses directly through Panama, as seen in Figure 2.

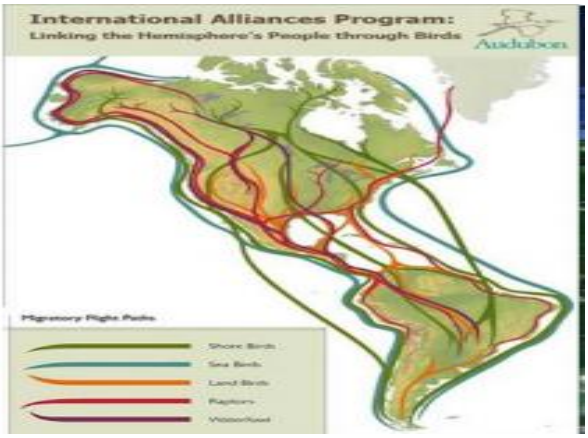



Figure 2: Bird Migratory Routes Through North and South America (National Audubon Society)


Figure 3: Fall Migratory Routes in Panama (Panama Audubon Society)

Figure 3 shows that the estimated route in the fall cuts through Tocumen International Airport. From 2013 to 2015, during the migration months (April and August) of black vultures, there were averages of twelve and twenty-six bird strikes, respectively, per month. In comparison, in the remaining months of the year, there was an average of only eight bird strikes per month (Copa Airlines, 2015). Therefore, the migration months of the black vultures seem to cause a substantial risk for bird strikes. In addition, the aforementioned thermals at the airport, allow the black vultures to coast around in the sky. One of the theories for why there are strong thermals at the airport is the notion that the black runways and tarmac soak up heat from the sun, and as the heat leaves and rises, it creates a thermal. Another possible theory for the existence of thermals at the airport is that the ongoing construction at the airport mentioned previously is releasing energy as heat, adding to the thermals, and therefore allowing birds to travel easily near the airport.

Finally, the surrounding area seems to be the main cause for a considerable amount of birds remaining in the area year round. The nearby area of the airport has three of the basic needs of

survival for any existing creature: water, shelter, and food. Tocumen International Airport is in close proximity to Panama Bay, and also several wetlands and mangroves, which are swampy, wooded areas with several trees, otherwise known as the ideal nesting area for several birds including black vultures. Some of these wetlands are actually part of airport property, which means that the airport could destroy these wetlands in order to destroy the birds' homes (Domínguez, 2015). However, Tocumen International Airport has made it clear that they will only fund a bird strike prevention plan that is guaranteed to succeed (Domínguez, 2015). The homes of the black vultures and other birds are made even more suitable by the severe waste buildup issue in the neighborhoods on the north end of the airport, allowing the vultures to scour through the waste in search of food. Waste within the airport property also is a food source for local wildlife, including birds. According to several employees at Tocumen International Airport, they believe that this waste is the main reason why birds flock to this area. There is some data to back this claim, as the runways in the direction of the northern neighborhoods with excess waste, such as runway 03L in the figure shown below taken by the previous IQP team, experience nearly double the amount of bird strikes the other runways encounter, leading to the assumption that the waste buildup is a major cause of the bird strikes (Copa Airlines, 2015).


Figure 4: Layout of Tocumen International Airport (Cheng, 2015)

Authorities at Copa Airlines had heard of the success that Guayaquil in Ecuador experienced in reducing bird strikes at their airport by not only implementing nets in nearby wetlands, as previously mentioned, but also by fixing their nearby waste management problems (Cheng, 2015). Now, Copa Airlines has sponsored this project to suggest improvements for the waste management system for the nearby neighborhoods as well as within the airport.

## 5.2 The Tocumen Community Current Waste Management System:

Despite being one of the richest countries in Central America, Panama has the second worst income distribution in Latin America, and almost twenty-five percent of the population lives in poverty. Panama is, however, a rapidly developing country and has one of the fastest growing economies in Latin America (Central Intelligence Agency, 2016). One of the byproducts of this economic boom is the excess of waste in the communities, as the waste management systems

have not yet caught up to the times. Due to inconsistent waste pickup, large waste heaps pile up on the sides of major roads, bus stops, and overflowing dumpsters in the few areas they exist. This uncovered waste is easily accessible for black vultures, which raid the refuse heaps looking for food. In interviews with locals from these nearby neighborhoods north of the airport, as well as interviews with a local representative from the waste management company, the previous IQP team learned that waste is supposed to be picked up three times a week, but waste seems to be picked up only once a week (Cheng, 2015). In addition, due to the fact that the neighborhood streets are too narrow, the waste collection trucks cannot reach every individual house, which means that dumpsters can only be placed on main roads. However, according to the locals, the dumpsters are always overflowing, missing, or broken, which leads to the easier solution of simply dumping the waste in the main road, or at the bus stop in order to keep the waste away from their houses.

The locals believe that while this waste management plan of a pickup three times a week worked about ten to fifteen years ago, it is no longer feasible, as the population and amount of waste has dramatically increased since that time and the waste management plan has not adjusted. It appears as though the local communities have accepted the waste buildups as part of the cultural norm, and do not expect any changes. While these nearby neighborhoods are not particularly poor, the locals have established in interviews that they would not be open to paying more money for an improved waste management plan, as they already pay what they see as too much money for a plan that does not even function properly. One of the problems that would be potentially encountered is the cultural norm of open dumping of waste, or continually utilizing a waste management plan (Cheng, 2015). Part of the reason why this difficulty may arise is the fact that the locals may question the motive for improving their waste management system. If the locals believe that the real motive for this program will be in order to help Copa Airlines have less bird

strikes and therefore not lose as much money in damages, they would care less and stick to their normal routines. They must be convinced to participate in programs or recommendations designed to improve their situation. The success of this plan hinges on the ability to gain the local neighborhood's support.

# Methodology

The overall goal of this project is to prevent bird strikes from occurring at Tocumen International Airport in Panama. Through recommendations, improvements can be made to the waste management plan for the surrounding community as well as the airport itself. In order to achieve this goal, the following objectives were created:

1. Assess the state of waste management in Tocumen community, as well as the airport.
2. Identify the types of waste and causes of buildup, then attribute factors to the current waste situation.
3. Evaluate the level of knowledge about the waste situation among the stakeholders.
4. Determine the level of concern among categories of stakeholders.
5. Recommend improvements for the waste management plan in the Tocumen community and airport.

Based on the objectives presented, a methodology was developed in order to accomplish the project goals. These methods include, but are not limited to, conducting interviews, participating in on-site visitations, evaluating data obtained, and researching successful waste management practices. The following sections highlight the reasoning for each method as well as the various processes through which they occurred.

## Objective 1: Assess the state of waste management in Tocumen community, as well as the airport.

In order to achieve a better understanding of the waste situation in Tocumen, research was conducted, including, but not limited to, on-site visitations and interviews in order to assess the waste management system in place. The data collected during the conducted research was analyzed. The information found will be compared with other cases around the globe in order to develop recommendations to improve the waste management system.

*On-Site Visitation of Community and Airport:* Through visitations of the areas that are most affected by the waste problem, the situation at hand was more closely observed and more thoroughly evaluated. Photographs of the afflicted areas were taken and a few locations with high concentrations of waste were identified.

*Interviews with Tocumen Residents:* In the Tocumen community, interviews occurred with multiple community members of differing age and gender. Due to the broad nature of the problem regarding the buildup of refuse, the buildup may have had different effects on different people. Interviews with community members were kept brief, lasting about five minutes each, and due to the small number of questions for each community member (Berg, 2012 pg 127). Goals of the interviews with the community members with regards to the objective include how each member disposes of their waste, if they are satisfied with how refuse is currently handled, and if the presence of waste in the streets affects their lives. Due to the time constraints of the project period, interviews were conducted until the overall opinion of the community was understood. A structured list of questions was used to accomplish the goals. This data was then analyzed through Google Spreadsheets in order to find answer similarities and trends. A Copa

Airlines or airport staff member was present in order to aid with translation in order to fully comprehend responses. The questions asked revolved around opinions on the presence of refuse, in addition to questions on spending for the waste management plan, if they are satisfied with that plan, and how waste is handled by the community. Lastly, conversations were kept confidential.

*Interviews with Tocumen International Airport and Copa Airlines Staff:* Interviews were conducted with representatives from the airport sponsor, Copa Airlines, to obtain insight into the state of waste management in Panama. Staff members have experience in the surrounding areas and with the waste problem. From these members, ideas were obtained regarding the correlation between the waste and the bird strikes that are occurring. The interviewees included, but were not limited to operational managers, the Copa ground safety manager, the Copa ground safety investigator, and the Tocumen public relations manager. Seeing as though this group is too small to warrant a survey, interviews are the most plausible method (Berg, 2012). Since these individuals work closely with an extensive international clientele, limited use of a translator was utilized given they have some knowledge of the English language. For all interviews, notes were taken, and data was collected.

*Research of Best Waste Management Practices from Similar Cases:* Problems with waste management are a common issue throughout the world. Pieces of successful practices can be applicable to the situation in Tocumen. Research was conducted on various case studies involving similar problems, including where the country in question was developing and undergoing major population growth and urbanization. This research is aforementioned within the background portion of this report.

## Objective 2: Identify the types of waste and causes of buildup, then attribute factors to the current waste situation.

In order to mitigate bird strikes, sources of bird attractants must be contained. At this point in time, a major cause of the bird strike problem is the waste buildup in proximity to Panama's Tocumen International Airport. Therefore, an investigation of the sources of the buildup is needed. Through the collection of the information, recommendations can be developed in order to improve the waste buildup and thus reduce bird attractants.

*On-Site Visitation of Tocumen Community:* As mentioned previously, firsthand observations of the situation were obtained by visiting areas with a buildup of waste. Information such as the size of the community, layout, extent of buildup, and preferred language of the residents was vital to conduct interviews and visitations. The concentration and extent of waste buildup was observed during periods in the field. Also, while in the field, behavioral observations of the residents were made regarding how waste was disposed. As mentioned in objective one, interviews were conducted with local residents. Questions were asked in order to obtain the reason for the buildup of refuse according to the community members. Observations made and data collected during the visitations were recorded and then further analyzed with Google Spreadsheets to fulfill the goals of the project.

*Observations of the Waste Management Company at Tocumen International Airport:* The waste management company, Servicios Tecnológicos de Incineración (STI), handles the international waste of the airport. The waste removal process of the international waste was observed in its entirety with explanations of the process by the acting operational manager of Tocumen

International Airport. Observations of the process were noted and photographs were taken to further document steps in the removal process.

## Objective 3: Evaluate the level of knowledge about the waste situation among the stakeholders.

In order to implement a successful waste management program, support from the community is essential. Through cooperation with the people in the area, waste management solutions can be conceived based on the needs of the residents. Without support of the residents, the system will not last and the excess waste will continue to attract birds to the area.

*Determine the Knowledge of the Residents Concerning the Impacts of the Waste Buildup:* Residents were interviewed in order to gather an overall idea of the community's opinion on the waste management system in place. Data on waste disposal methods was collected and evaluated. Possible improvements to the community education program can be suggested to inform the residents about proper disposal methods the potential harms of waste buildup.

*Observe the Community Education Program:* Through research presented in the background portion of this report, an education program to implement behavioral changes to waste management would be best suited for children in school. Autoridad de Aseo, a waste management authority, recently established a community education program to educate a small portion of the local primary schools. This community education program was observed and the leaders of the program were interviewed in order to evaluate possible improvements to the program.

## Objective 4: Determine the level of concern among categories of stakeholders.

In order to alleviate the problem of bird strikes occurring at the Tocumen International Airport in Panama, cooperation of different stakeholders is necessary. Through contact with the stakeholders, the concern for the waste problem can be measured. In order to make recommendations to improve the waste management situation to help mitigate bird strikes, Copa Airlines, the airport, other airlines, the government and the residents themselves will need to cooperate. The correspondence with the stakeholders was evaluated in order to accomplish the goals of the project.

*Interview with Copa Airlines Staff:* Through correspondence with the sponsor, the concern of the bird strikes was determined. Also, by examining bird strike data collected by the company, the desired effort to mitigate bird strikes can be examined. With the developed recommendations, collaboration by Copa Airlines with the airport and community can yield improvements to the waste management system.

*Interview Tocumen International Airport Staff:* Copa Airlines is not the only airline operating at Tocumen International Airport. Other airlines use the airport as well, some of which are Aeromexico, Air Europa, Air Canada, Air France, etc. Interviews were conducted with staff of the airport in order to determine the level of concern at the airport about bird strikes. Most costs immediately affect the airlines themselves, but costs for the airport might arise as well when bird strikes occur. In addition to Copa, other airlines operating at the airport are affected by bird strikes, and they may support suggested improvements to the waste management systems proposed by this report.

## Objective 5: Recommend improvements for the waste management plan in the Tocumen community and airport.

The report confirms that the waste buildup is indeed a main attractant of birds in proximity to the airport. Solutions to the bird strike problem were developed by addressing the waste buildup. From the information gathered through the previous objectives, recommendations were developed to improve the current waste situation.

*Suggest Specific Waste Management Improvements:* This strategy will be determined from several factors, including, but not limited to, the types of waste present, the results from the conducted interviews, the extent of the success of the waste management company, and the successes of different strategies in similar situations worldwide.

*Community Education Program:* Depending upon the interview results, the community education program can be improved and extended. Improvements to the program include suggestions for better waste disposal habits, and possibly improve relations between the municipality and the community. The community education program may improve the quality of life of in Tocumen, while also mitigating bird strikes.

*Present Findings and Recommendations to Copa Airlines and the Airport:* The recommendations and findings were presented to both the sponsor as well as airport administration. The results of the project suggest that the stakeholders work with the government and the waste management company to improve the problem. The recommendations are further described later in the report in the Conclusions & Recommendations section.

# Findings

After conducting interviews, meetings, and visits within both the Tocumen community and the airport itself, the following findings were deduced through analyzing the data. Overall, the Tocumen community was found to have large amounts of waste present in the street, while the airport was deemed to have only a minor waste management issue.

**Tocumen Community Findings:**

**1. The existing waste collection system present in the Tocumen community was determined to be inconsistent, leading to confusion amongst the residents as to what the waste collection system truly accomplishes.**

The sheer amount of waste along the streets clearly indicates that there is a problem with the current method with which waste is being handled. Therefore, the first goal of the interview of each resident was to determine whether the resident was comfortable or content with the current amount of waste roadside. Predictably, ninety-five percent of our interviewees in the community reported "No" in response. This answer clearly indicates a desire for change and improvement in regards to the amount of waste present on the street.

The next step was determining how much of the issue the waste management company was responsible for. A critical piece of information in regards to waste management is the collection schedule, as this lets residents know when to place their waste bags outside for pickup, whether it is roadside for door-to-door collection, or in a designated collection zone. However, when the residents were asked what days the waste collection trucks arrive to collect the waste, a large variety of answers were provided, ranging anywhere from daily pickup, to pickup once a month, and, in some cases, residents not even knowing, as shown in Figure 5 below. One possible explanation for the major discrepancies is that the interviewees

live in different areas of Tocumen community. However, the lack of awareness of the collection schedule signifies a lack of communication between the waste collection company and the residents. Also, despite the discrepancies, it is worth noting that the most common answers were weekly pickup and biweekly pickup, which could explain why the waste roadside builds up over time.

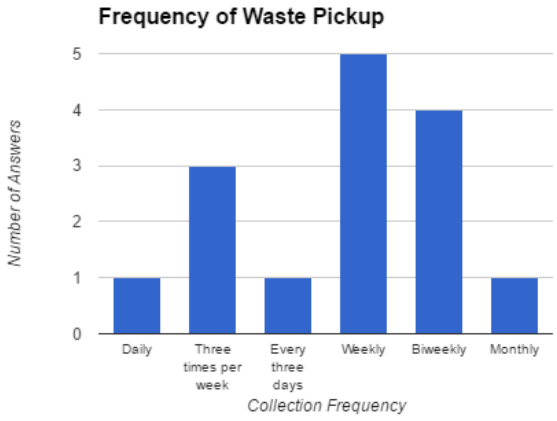



Figure 5: Frequency of waste collection according to residents of the community.

In an attempt to discover other issues with the waste collection process, the residents were also asked what they believed the waste management company could do better. The two most common answers involved the installation of a greater number of dumpsters and an increase in the frequency with which waste collection trucks made pickups. As stated earlier in the report, the neighborhood roads are too narrow for the waste collection trucks to drive down, which means that the residents living on these narrow streets must bring their waste to the main road. However, dumpsters are scarce, leaving the residents with no choice but to pile their waste along the main road near bus stops or street corners. The lack of dumpsters, or even large waste bins, clearly contributes to the amount of waste in the streets. In addition, small animals were observed foraging through the uncovered waste as highlighted in Figure 6, something that the dumpsters could help prevent. In regard to the residents' other most common answer, a more frequent pickup of waste, this is something the waste management company could handle

internally. It is quite clear that there is a copious amount of waste roadside illustrated in Figures 7 and 8, and a large number of residents leaving their waste alongside the main road were observed. The waste builds up rapidly, and it is evident that the number of trucks is not sufficient. Earlier in the report, it was noted that Panama's population is experiencing rapid growth, and the waste collection process has not evolved to keep pace. For example, when interviewing a man who had lived in the Tocumen community for the past forty years, he stated that the waste collection trucks have made pickups on the street corner near his house, represented in Figure 6. While this system may have been adequate in the past, a drastic increase in population and thus an increase in waste has made this biweekly pickup system an insufficient method. Although this specific example came from just one resident, a stagnant, outdated waste collection schedule was noted in interviews with several residents.

Figure 6: Small birds scavenging amongst the waste

Figures 7 and 8: Waste roadside

There are noticeable problems with the current waste management collection process, as it is inconsistent, sets no recognizable schedule for pickup, and is outdated in terms of the number of trucks employed and the number of collections performed. In addition, there are almost no dumpsters present for residents to place their waste. However, the blame for current state of the waste situation cannot be placed entirely on the waste management company. It is clear to see that the waste management company will not be able to fix the entire waste situation on their own. Therefore, the residents must learn to eliminate or, at the very least, minimize their contributions to the problem in order to achieve the ideal waste management system for the Tocumen community.

**2. The methods of disposal of waste varied throughout the interviewed residents, and included both proper and improper handling of waste.**

As noted previously, numerous residents were witnessed leaving refuse roadside. This led to asking several residents how they disposed of their waste. There were six different answers provided by the residents during the surveying period, as indicated below in Figure 9. However, over half of the total number of answers (fifty-five percent) could be deemed improper waste handling, while the remainder of the answers could be recognized as proper waste treatment.

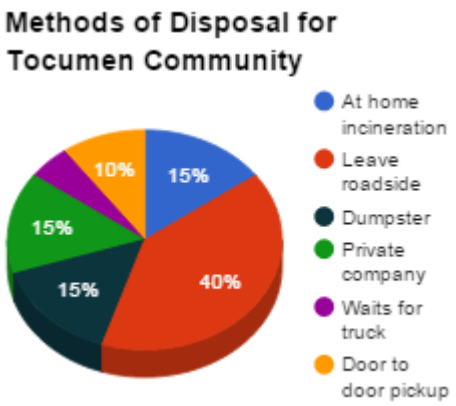



Figure 9: Methods of waste disposal for Tocumen Community.

First, the various proper waste treatment methods will be discussed. These four methods are as follows:

- Door-to-door collection
- Placement of waste within a dumpster
- Utilizing a private waste management company
- Waiting for collection trucks to arrive

Unfortunately, door-to-door pickup is not an option for most residents, as the majority of the streets in the Tocumen community are too narrow for the waste collection trucks. There seems to be only a small percentage of residents with access to door-to-door pickup (fifteen percent), although the sample size conducted may be too small to know definitively. As for the residents who do not have access to door-to-door pickup, those who properly handle their waste are more likely to put their waste in a dumpster. However, as noted earlier, there are not many dumpsters to be found, which is likely the cause of the low number of residents interviewed using dumpsters (fifteen percent). For example, one resident that was interviewed stated that, although she places her waste in a dumpster, she has to walk ten minutes from her house to reach the nearest one. The next handling method involved some residents paying an undisclosed amount to an unnamed third party to remove their waste. This solution is not feasible for other residents who may not be able to invest in a third party waste removal company. Finally, one interviewee stated that "when he sees the waste collection truck, he runs up to it with his waste and throws it in." While this is classified as proper handling of waste, it is still a questionable method, as the resident should not have to go to such lengths to make sure his waste gets in the truck.

Most commonly, polling at forty percent amongst residents that were interviewed, the residents will leave their waste roadside. It has become apparent that this is a cultural problem in this community, as several residents see nothing wrong with leaving their waste in the streets, and express that leaving waste roadside has always been the way they take care of their waste. This method of disposal is the cause for

Copa's interest in improving the waste situation, as the waste left in the streets is a major attractant for birds, leading to an increased risk in bird strikes (Domínguez, 2016).

**3. Due to a large percentage of residents mishandling waste, a large amount of refuse was witnessed along the roadways.**

According to worldatlas.com, the population of the Tocumen community is approximately 88,500. Therefore, based off of the data from the interview questionnaire (forty percent), and estimating that the average household size is four people, approximately 8,850 families in the Tocumen community leave their waste in the streets. As mentioned throughout the findings section, there are a number of clusters of waste throughout the community. Several residents were witnessed leaving waste roadside with varying amounts of waste during the surveying period. Some residents would simply leave a bag of waste on the way out, while others would use a wheelbarrow to dump uncovered, non-bagged waste into a ditch filled with waste, as seen in Figure 10 below. While a significant amount of waste was bagged, a great deal of loose waste was present in all of the waste piles witnessed throughout the community. This not only attracts even more wildlife, but also makes waste collection challenging for workers. At street corners that have a ditch filled with waste, the waste collection trucks typically use a type of scoop attached to the truck to gather waste. However, this is a flawed method, as much of the waste gets left behind as indicated by Figure 11 where waste was present the morning after the scheduled collection according to interviewed residents. Through observation as well as from interview responses, it was made apparent that the ditch becomes increasingly deeper with each "collection", and dirt is scooped up along with the waste. On flat, solid surfaces where the waste collection trucks operate, such as bus stops, workers must pick up waste by hand. Through speaking with residents, it was discovered that the pickup spots for waste collection trucks have seemed to evolve into wherever there are large amounts of waste. However, because there is always so much waste, the trucks typically cannot remove all of the waste in each area, as they are responsible for other areas as well. Before long, the waste trucks reach maximum capacity, and

then cannot collect the rest of the waste they are responsible for. While the performance of the waste management company has been less than satisfactory, the habit of open dumping of waste by the residents make it next to impossible to improve the current waste management system.

Figure 10: Resident using a wheelbarrow to dump uncovered, non-bagged waste.

Figure 11: The morning after waste collection.

**4. A recent implementation of a youth community education program at a local school regarding proper waste handling habits could serve as a starting point for long-term cultural change in the community.**

This program, organized by Autoridad de Aseo, a government agency, was implemented in May 2016 and runs weekly for six months. In the program, there are about twenty-five children, who are roughly ten

years old. Students from different classes are selected at random, with the goal of forming model students within their own classes. The goal is for students involved with the program to share what they have learned with their friends and families in order to spread the teachings of the program.

In La Siesta, in the school where this program takes place, the students learn several different things about waste by engaging in a question and answer dialogue with Autoridad de Aseo employees. For example, one week, students were asked questions such as "What types of waste do you encounter mostly?", followed by holding up photos of various types of waste with decomposition time on the back. In addition, students were asked "What problems do you see when you are walking on the street?", followed by an additional activity where students wrote on sticky notes various problems they saw at school in regards to waste, as well as things they would like to improve. Then, in the following week, students would look into possible solutions for ways to improve the waste situation at the school with the help of the government employees.

While attending the program at the school, it was clear to see that the children were excited and interested in the program as seen in Figure 12. Various students were shouting out answers, and were quite interested in how waste management systems operate in the United States. The optimistic view is that over time, these students will expect better resolution of the waste situation, and will not stand for the waste in the streets. Though this program will not be helping the current waste situation in the community improve in the near future, the program is a step in the right direction towards a generational viewpoint shift at how waste is viewed.


Figure 12: Students taking part in activities during the education program.

**5. Panama lacks recycling programs, especially for plastic.**

Through correspondence, interviews, and observation it was made apparent that in Panama the recycling of plastics was lacking. As shown in Figure 13, on a visitation to a local beach on the edge of Panama City itself, an overabundance of plastic could be observed spanning a considerable distance up and down the shoreline. Plastic also appears to be the most abundant type of refuse present in the Tocumen community waste buildups. Plastic is highly disregarded, and much of it present on the beach originated from various sources along local rivers according to Jaime Arosemena of Copa Airlines.

Figure 13: Plastic waste, mostly bottles, on a local beach in Panama City.

**Airport Findings:**

**1. International waste is collected twice daily by Servicios Tecnológicos de Incineración (STI), totaling approximately 300,000 kg of monthly waste (Appendix B).**

In an interview with the Operational Manager of the airport, Jorge Lizarraga, the waste collection process was detailed for waste coming from the numerous international flights, otherwise known as international waste. The waste collection process, as shown in Figure 14, takes place twice a day first, from 8:30 a.m. to 11:00 a.m., and again in the evening from 6:00 p.m. to 7:30 p.m. STI makes thirty-two points of waste pickup at the three different terminals (main terminal, cargo terminal, and private hangars), but a majority of the waste comes from the main terminal. The waste collection process removes approximately six tons of waste every trip, with approximately 350 waste bags removed in the morning collection process, and about 270 waste bags in the evening process (Lizarraga, 2016). This totals to approximated value of 300,000 kg of waste every month that is removed from the airport (Appendix B). As a reference point, a flight consisting of 400 people will have roughly thirty-five bags of waste.

Figure 14: Waste collection at the main terminal, around 8:30 A.M.

**2. While the international waste from Tocumen is currently transported to a waste incineration facility in Colón, a future plan is in the works to build a waste incineration facility on-site near the cargo terminal.**

According to Carol Dominguez and Jorge Lizarraga, due to regulations, all international waste must be incinerated, hence the contract with STI, which specializes in waste incineration. After the waste is collected at the airport, the trucks travel approximately fifty miles to the waste incineration facility in Colón (Lizarraga, 2016). However, this system could be improved. For example, the long drive to the waste incineration facility takes some time, allowing waste to build up again quickly. Also, by analyzing the data from the previous section, one can see that there is more waste in the morning than in the afternoon, which means that the times of collection are not set at the optimal hours. Ideally, the amount of waste should be about the same in each collection process. This way the airport would be able to provide the proper number of bins needed to collect the amount of waste.

For these reasons, the airport operations staff has begun plans to build an on-site incineration facility at the airport (Lizarraga, 2016). This would be a joint project with Oproler, a construction company in Panama, but has yet to be finalized at this time. With construction on the new terminal underway, there will be an additional twenty-two waste pickup locations, causing a need for either another truck, or another process. By building an on-site waste incineration facility, waste could be collected multiple times each day at all four terminals. However, as noted previously, this plan has not yet commenced.

**3. Insufficient bin coverage and bin capacity were noted at the various ramp and gate locations at the terminal.**

Overflowing waste bins can regularly be seen throughout the airport ramps, as seen in Figure 15, while others remain empty. In addition, several of these waste bins are uncovered, allowing small birds to sift through the waste. Due to the quick turnaround of twenty minutes that takes place in between flights,

workers do not have time to bring waste bags from one gate's waste bin to another gate's receptacle (Escobar, 2016). However, this does not justify leaving waste bags on the ground, uncovered, for several hours until waste collection arrives. There is an undeniable need for expanded bin capacity in order to handle the excess waste bags, especially with an ever-increasing number of clientele that directly correlates into an increased amount of international waste.

Figure 15: Overflowing, uncovered waste bin at the airport.

**4. Low quality waste collection bags are transferred by hand by STI workers to a waste collection truck.**

In an interview with the Cabin Services Manager for Copa Airlines, he specified that the thickness of the waste bags was 0.8 mil, or 0.02 mm, which is the lowest allowed by regulations (Escobar, 2016). While witnessing the waste collection process at the airport, several waste bags were noticed to be ripped, with refuse spilling out. Sometimes, the waste collection workers would not notice, and the loose refuse would be left behind, as seen in Figure 16.

Figure 16: Refuse unnoticed and left behind by waste collection workers.

**5. Loose refuse in ramp areas attracts birds, despite the current bird deterrents in place.**

There is indeed a problem of loose refuse in the ramp area of the airport. While the amount of loose refuse pales in comparison to the amount presently found in the Tocumen community, it is still a problem nonetheless. In addition to the waste that spills out of the ripped waste bags, a noted contributor to the loose refuse problem is the workers themselves. According to both Jorge Lizarraga and Carol Dominguez, many workers simply throw their food waste on the ground after eating. As noted earlier in the report, several of the workers at the airport actually live in the Tocumen community, which makes these workers no strangers to the cultural habit of open dumping of waste. However, this behavior is unacceptable, as small birds are attracted to the waste. While walking through the airport ramps, a bird was photographed with a worker's food waste in its beak as captured in Figure 17.

Figure 17: Bird with a worker's food waste in its beak.

Foreign object debris, or FOD, is a common term used in airport jargon. Through visitation of the airport and interviews with Jorge Lizarraga and Michael Pacheco, a USDA Biologist working with Tocumen at the time, FOD is a hazard in any airport. The website fodcontrol.com defines FOD as "an important safety and quality control concept in any aviation, aerospace, manufacturing, warehouse, shipping, military or similar environment where small debris, loose objects, wildlife and even stray humans have the potential to cause: damage to manufactured equipment; injury to employees, visitors or passengers; production delays or safety violations." Tocumen has many receptacles for FOD, however some are uncovered and there is still stray refuse in the ramp area which highlights the lack of concern from the airport employees as seen in Figure 18.


Figure 18: Uncovered receptacles for FOD.

Small birds fearlessly sift through waste, and they too are a risk for being involved in bird strikes. For example, our team examined the remains of a small pigeon that was involved in a bird strike. These smaller bird strikes pose no harm to aircraft but still represent a danger to the wildlife involved. The airport has attempted to take measures to scare away birds by implementing sound deterrents at the airport. One example is the sound speakers which repeatedly issue a predatory bird cry. If these speakers are not continually moved around the airport, over time, the birds may become acclimated to the noise, and will not be frightened (Pacheco, 2016). Another aspect of these speaker systems that could be looked into is the actual predatory bird cry. Depending on the sound chip in the speaker, the predatory bird cry could be a bird not native from the region, which most likely would not affect the small birds (Pacheco, 2016). However, current bird cry is being used is unknown. Other sound deterrents, such as firecrackers and flare guns, are used by the airport as needed. The limitations of the various sound deterrents can be found earlier in the report in the background section.

# Conclusions & Recommendations

**For the Tocumen Community Representatives:**

**1. Establish designated waste disposal locations**

As stated previously in the findings portion of this report, door-to-door waste collection is not feasible for many of the households within the Tocumen community. Many residents dispose of their waste away from their homes, often near the main street such as areas near intersections and at bus stops. There are some places along the main street that have evolved into waste disposal locations showing that residents are willing to dispose of their waste in common locations. By establishing designated waste collection areas agreed upon by the waste management company and the community, this may in turn encourage a large majority of residents to only dispose of their waste in these specified areas when collection is needed by the resident. If waste is disposed in fewer well established locations, there will be less stops to make during the collection route and the waste management system as a whole will be more organized and efficient.

**2. Establish a fixed waste collection schedule with Autoridad de Aseo**

While interviewing members of the community, it was made apparent that there is confusion with the collection schedule. If residents are unaware of the schedule, they will not know when the waste is to be collected. A set schedule clearly communicated between the community and the waste authority (Autoridad de Aseo) will allow for the community to collaborate with the waste collection workers on collection days so that no stray refuse is left behind. Also, a set schedule holds both residents and the waste collectors accountable. The consistent collection times calls for residents to organize when to make trips to the collection locations instead of waiting for the truck. They also provide the residents with a way to easily keep track of the success of the waste management company. For example if residents notice repeated failure of the collection company at an established pick up location and time, they can call

for a community representative to monitor that location and hold the waste management company accountable. With the current system, the disorganization makes it impractical to monitor the waste collection to any degree.

**3. Collaborate with Autoridad de Aseo to improve waste collection efficiency**

Due to the disorganization in the waste collection process, the waste management is inefficient. There are many ways to improve the efficiency of this system such as the specified collection areas and collection times as stated previously. However there are other ways to increase efficiency. While conducting interviews, some common responses arose. First, an occurrence both witnessed on visits to the field and described by local residents is that often a truck will fill completely before completing its collection route leaving refuse behind and allowing leftover waste to accumulate over time. An increased capacity is needed and could come in the form of added trucks or also be accounted for by an increased collection frequency in the area. With the growing population of Tocumen, the waste collection capacity needs to also grow to account for the population growth.

**4. Collaborate with Autoridad de Aseo to obtain more waste collection receptacles**

Through on site visitation of the community, loose refuse and torn bags were observed. Receptacles for waste were a rarity, the exception possibly being for business use, but even for businesses, there was a significant lack of outdoor waste collection receptacles. In order to contain and organize the waste that is ready for collection, public dumpsters should be stationed at specified points for residents to dispose of their waste. The needed capacity of the dumpsters for the area's growing population will need to be evaluated by the waste management authority. Not only will the dumpsters provide a place to put refuse, but it was also prevent a large amount of animals from feeding on the waste. The amount of loose refuse will be significantly be reduced because of the ability of the dumpster to prevent refuse from being blown around by wind or moved by animals. The containment of the waste to dumpsters will reduce the animal

attractants in the area substantially. Dumpsters will also improve the quality of life in the area as well as making the area more aesthetically appealing to tourists by reducing the amount of waste in the streets near the airport.

In the future, the government could possibly invest in trucks that can lift dumpsters and empty them. This will in turn reduce the need for workers to collect waste by hand and ideally reducing the amount of waste that does not enter the truck during transfer of bags into the truck. However, the trucks currently being used do not appear to have this ability. Even so, dumpsters can ease the waste collection process for both the residents and the collection workers.

**5. Expand community education program on waste management.**

The current community education program established by Autoridad de Aseo is a significant step forward to improving the way that residents view waste. This program is well received by the children involved as stated previously, and should be expanded to involve more children. Analysis of the program as well as an interview with the leaders of the program has brought about some recommendations to improve the effectiveness of the program. Firstly, the Autoridad de Aseo could improve the effectiveness of the teachings by encouraging the school administrators and staff to encourage the proper handling of refuse. This can be achieved by enforcing a no littering policy on school grounds to teach that mishandling waste is wrong as well as utilization of posters emphasizing the benefits of a clean city. As referenced, in a previous project in Bangkok, success of implementing a community education program involved utilization of the teachers in the school as well as positive messages regarding waste management through such means as posters (Aroonsri, 2014).

The community education program could be extended to the residents as well. Positive messages could also be displayed in the community emphasizing proper handling of waste, for example in view of the established waste collection locations. One method to promote proper waste management is through utilization of public posters (Aroonsri, 2014). The community could also be educated about the aforementioned health hazards involved with mishandling waste as a means of motivation to improve the situation. An informed community about the specified and proper waste management plan will be more willing to work toward keeping it successful. These inexpensive ways to institute social change regarding refuse could be very appealing to the waste management authority.

**6. Establish a recycling program.**

A recycling program can be seen as a valuable tool for waste management systems. As previously stated, Panama does not have a cultural emphasis on recycling; however there are established recycling companies. As seen in the project that occurred in Bangkok, recycling for income can be a very effective manner for reducing waste in the streets (Aroonsri, 2014). If the Autoridad de Aseo can encourage recycling and possibly establish a system for residents to recycle plastic in exchange for monetary compensation, many people will become involved. People in developing countries are motivated to make money through scavenging (Zhang, 2009). An established recycling program not only reduces the impact on the environment, but can be a relatively inexpensive way to remove waste from the cities and surrounding areas.

**<u>For Tocumen International Airport and Copa Airlines:</u>**

**1. Provide larger or more adequate amounts of waste collection bins in ramp areas**

The waste collection bins stationed under each ramp, when utilized to their maximum capacity, often times do not provide enough space to fit the amount of international waste that is being taken off the planes. As a result of collection only occurring twice per day, the bins quickly become overfilled forcing

workers to place the collection bags on the ground near the bins, which in turn places them at risk for tearing. The inconsistency in the number of bins per ramp also exacerbates the problem, as some ramps have only one bin while others have multiple bins that are never used. It is clear that, with the waste collection schedule being as it is, there is a need for implementation of either larger collection bins, or a greater and more consistent number of bins per ramp. By increasing the capacity that the total number of bins can handle during the periods between collections, there can some alleviation to the loose waste issue.

**2. Establish an employee education program emphasizing foreign object debris (FOD)**

If employees are aware of the dangers associated with FOD, a higher level of concern among the workers in the ramp area will ensue. Similarly to the proposed programs at the school, a litter free work environment can be effectively enforced in the airport. Part of the employee training process could include informing the new employee about FOD as well as the non-littering policy of the work environment. Also, by washing and cleaning waste receptacles periodically, loose waste will accumulate less in the receptacles. By creating accountability of controlling refuse, there will be less made available to birds and other animals, reducing possible damage to aircraft.

**3. Provide higher quality waste collection bags to limit tearing**

Although the waste collection bags for international waste comply with regulations, they do so with the smallest allowable thickness, roughly 0.8 mil, or 0.02 mm (Escobar, 2016). As was previously stated, there were multiple occasions during the observation of the international waste collection process where the bags would tear while being loaded into the collection truck, leading to a spillage of refuse onto the ground which oftentimes was not completely recovered. The thickness of the bags may also leave them susceptible to puncture by birds or other wildlife. A relatively simple solution to this problem would be

to implement thicker waste collection bags on the ramps. This way, a major contributor to the issue of stray waste on the ramps is minimal or, ideally nonexistent.

**4. Limit transfer of waste by hand within the airport**

While observing the international waste collection process, it was noted that much of the transfer of waste is done by hand. Utilization of trucks equipped to lift and empty dumpsters can increase efficiency of the waste removal process. It will also reduce the amount of loose waste that is dispersed during the waste transfer process. This can be a more costly method, however it should be explored during the construction of the new airport waste incineration facility and when establishing the new waste management system.

**5. Ensure waste collection bins are covered when not in use**

As with every type of waste receptacle, failing to place a cover over the waste leaves the bags inside vulnerable to puncturing via wildlife or other outside factors. The international waste collection bins are no exception. The lids of the bins that were found to contain actual waste inside were rarely closed, leaving the waste inside exposed. As evidenced by the Tocumen community, this can be a major attractant of unwanted wildlife, most notably birds that arrive and peck at the bags in search of food, leading to the aforementioned puncturing. In order to prevent this potential attraction, it is recommended that the waste collection bins on the ramps remain closed when not in use by staff. This could be reinforced in the employee training program, and also by posting signage in the ramp area as a reminder.

**6. Proceed with plan to build an on-site incineration facility**

Per regulations, STI transports the international waste from the ramps to an off-site incineration facility approximately 100 kilometers away from the airport in the city of Colón (Lizarraga, 2016). Here, the waste is properly incinerated and disposed of. One of the main issues with this disposal method,

however, is the potential for waste to fall out of the collection truck on the long journey to the incineration facility, as was pointed out by Jorge Lizarraga. The extended period of time it takes for the truck to drive to the facility and back is also problematic, as it does not allow for more frequent collection of international waste at the ramps. Plans are in place by the Tocumen International Airport to build an on-site incineration facility on airport grounds in order to address these issues (Lizarraga, 2016). No official construction has begun on the facility, though it is highly recommended that it be completed as quickly as possible in order to both help solve the loose waste issue and facilitate the introduction of other methods of waste reduction at the airport.

# References


Aeroweb. General Aviation Market Data. (n.d.). Retrieved from http://www.bga-aeroweb.com/General-Aviation.html

Airline Network News and Analysis. (2008). *Copa Airlines exploits location to develop hugely profitable Central American hub-and-spoke network.* Retrieved from http://www.anna.aero/2008/07/04/copa-airlines-exploits-location-to-develop-hugely-profitable-central-american-hub-and-spoke-network/

Allan, J. R., & Digital Commons @ University of Nebraska - Lincoln. (2000). *Costs of bird strikes and bird strike prevention*

Alternative Airlines. *Copa Airlines Routes.* (n.d.). Retrieved from https://www.alternativeairlines.com/copa-airlines

Aroonsri, P., Glynn, C., Kanjanawattana, S., McGlashan, K., Tassanakul, P., Weisgerber, B. (2014). *Developing a Sustainable Waste Management Strategy for the Khlong Toei Slum in Bangkok* (Undergraduate Interactive Qualifying Project No. E-project-030614-124215). Retrieved from Worcester Polytechnic Institute Electronic Projects Collection: http://www.wpi.edu/Pubs/E-project/Available/E-project-030614-124215/

Bates, J. (2015). Hub of the Americas. *Airport World*. Retrieved from http://www.airport-world.com/features/airport-profiles/5155-hub-of-the-americas.html

Berg, B. L., & Lune, H. (2012). *Qualitative Research Methods for the Social Sciences* (8th ed.), 53, 115-119, 127. Upper Saddle River, NJ: Pearson.

CAPA. (2015). *Panama's Copa Airlines poised for more rapid expansion and industry-leading profits*. Retrieved from http://centreforaviation.com/analysis/panamas-copa-airlines-poised-for-more-rapid-expansion-and-industry-leading-profits-121098

Central Intelligence Agency. (2016, March 23). The World Factbook: Panama. Retrieved from https://www.cia.gov/library/publications/the-world-factbook/geos/pm.html

Cheng, E., Hlavenka, T., & Nichols, K. (2015) *An Analysis of Bird Strike Prevention Methods at Panama City's Tocumen International Airport* (Undergraduate Interactive Qualifying Project E-project-102915-205833). Retrieved from Worcester Polytechnic Institute Electronic Projects Collection: https://www.wpi.edu/Pubs/E-project/Available/E-project-102915-205833/unrestricted/CopaBirdStrikePreventionMethodsInPanama.pdf

Copa Airlines. (2015). Bird Strike Data. Retrieved from Copa Airlines bird strike reporting database

Copa Airlines. (n.d.). *Company Profile.* Retrieved from http://investor.shareholder.com/copa/overview.cfm

Copa Airlines. (n.d.). *Corporate social responsibility - Workforce.* Retrieved from http://www.copaair.com/sites/cc/en/acerca-de-copa-airlines/pages/rse-colaboradores.aspx

Copa Airlines. *Our history* (2016). Retrieved from http://www.copaair.com/sites/cc/en/acerca-de-copa-airlines/pages/nuestra-historia.aspx

Copa Holdings. (2013). *Copa 2012 Annual Report Form 20-F*. Retrieved from http://files.shareholder.com/downloads/CPA/2651425539x0x658225/4FF5691C-5243-4B1F-BB76-C1D974FA8268/2012_Annual_Report__Form_20-F_.pdf

Cornell University. (2015). Black Vulture. *The Cornell Lab of Ornithology.* Retrieved from https://www.allaboutbirds.org/guide/Black_Vulture/id

Domínguez, C. (2015). Landscape around Tocumen International Airport [Personal interview of Previous IQP team].

Domínguez, C. (2016). General information about bird strike problem at Tocumen International Airport [Personal Interview].

DeFusco, R. P. & Unangst, E. T. (2013). *Airport Wildlife Population Management*. Vol. 39. Transportation Research Board.

Dolbeer, R. A., Wright, S. E., Weller, J. R., & Begier, M. J. (2014). *Wildlife Strikes to Civil Aircraft in the United States 1990–2013* (p. 1, Rep. No. 20). Retrieved from http://wildlife.faa.gov/downloads/Wildlife-Strike-Report-1990-2013-USDA-FAA.pdf

Escobar, I. (2016). Waste removal from Copa planes [Personal interview].

Heilbron, P. (n.d.). *Corporate social responsibility.* Retrieved from http://www.copaair.com/sites/cc/en/acerca-de-copa-airlines/pages/responsabilidad-social-empresarial.aspx

Heinz, M. (2016). Information on bird strike problem [Personal interview].

Henry, R.K., Yongsheng, Z., Jun, D. (2006). Municipal solid waste management challenges in developing countries - Kenyan case study. *Waste Management*, *26*(1), 92-100.
Kasarda, J. D. (2011). "Big plans for Panama." *Airport World*, *16*(03), 01-07.

Kapila, G (2014). Panama Tocumen readies duty-free tender for new terminal.

Kelly, N. E., Sparks, D. W., Devault, T. L., & Rhodes, O. E. (2007). Diet of Black and Turkey Vultures in a Forested Landscape. *The Wilson Journal of Ornithology,*119(2), 267.

Korfmacher, K. S. (1997). Solid waste collection systems in developing urban areas of South Africa: An overview and case study. *Waste Management & Research*, 15(5), 477-494.

Levesque, A., Pelletier, B., & Samuels, E. (2003). *Solid Waste Management in Costa Rica and the United States: A Comparative Analysis of Five Municipalities*. (Undergraduate Interactive Qualifying Project No. 03E018I). Retrieved from Worcester Polytechnic Institute Scanned Projects Collection: http://www.wpi.edu/Pubs/E-project/Scanned/03E018I.pdf

Linowes, R., & Brown Hupert, M. (2006). The tropical waste dilemma: waste management in Panama. *International Journal of Emerging Markets, 1*(3), 225-234.

Lizarraga, J. (2016). Information about waste collection process at Tocumen International Airport [Personal Interview].

National Transportation Safety Board. (2010). Loss of Thrust in Both Engines, US Airways Flight 1549 Airbus Industrie A320-214, N106US. *Accident Report Detail*. Retrieved from http://www.ntsb.gov/investigations/AccidentReports/Pages/AAR1003.aspx

Pacheco, M. (2016). Overview of waste problem and its effect on birds [Personal interview].

Plane Spotters. (2016). *Copa Airlines Fleet Details and History*. Retrieved from https://www.planespotters.net/airline/COPA

Raninger, B. (2009). Management and Utilization of Municipal and Agricultural Bio Organic Waste in Europe and China. *Workshop in School of Civil Environmental Engineering Nanyang Technological University, Singapore*

Smithsonian Tropical Research Institute. (2014, November 11). Panama Shatters Raptor Migration Record. Retrieved from http://www.stri.si.edu/english/about_stri/headline_news/news/article.php?id=1879

Tocumen International Airport. (2016). *Terminal 2.* Retrieved from http://www.tocumenpanama.aero/panama-ciudad-pty/terminal-2

Zhang, D. Q., Tan, S. K., & Gersberg, R. M. (2010). Municipal solid waste management in China: status, problems and challenges. *Journal of Environmental Management*, *91*(8), 1623-1633.

# Appendix A

## Interview Questions

Questions for Local Residents

1) How long have you lived in this area?
2) Are you satisfied with the current waste management system?
3) How do you dispose of your waste?
4) How often do you see waste being collected?
5) Do you feel like the waste management company does its job correctly?
6) If not, what do they do wrong, and what can do they do better?
7) Are you comfortable or content with the amount of waste in the streets?
8) Do you have any other suggestions of ways that would help the community rid itself of excess waste?

Questions for Jorge Lizarraga, Operational Manager At Tocumen International Airport:

1) How long have you been working at the airport?
2) What is your job/position here?
3) What company is in charge of handling waste at the airport?
4) How many locations does the waste truck make pickups?
5) How many times a day does waste pickup occur, and at what times?
6) How much waste is handled daily?
7) Where is the waste taken to upon being removed from the airport?
8) Approximately how much waste comes from each flight?
9) Do you feel the northern community's waste situation is a major reason for the number of birds present?

10) Why do you feel the waste situation near the airport is in poor shape?

11) Do certain runways have a higher rate of bird strikes than other runways? If so, which runway?

12) Are there any plans for the future to improve the waste situation within the airport?

Questions for Melissa Heinz, Wildlife Management

1) Are you aware of the bird strikes happening?
2) Do you keep track of them?
3) If so, is there any way we could get access to that data? If not/ Do you have an estimate?
4) Do you think the airport is at high risk?
5) In your opinion, to what extent do bird strikes affect the airport itself?
6) Are you currently doing something to prevent them?
7) Do you have any idea what might be causing them?
8) We have a strong belief that the waste in the surrounding neighborhoods is an important factor, do you agree with this?
9) How often do you think the waste is getting picked up at neighborhoods x, y, z?
10) Do you believe the job is getting done correctly?

Questions for Autoridad de Aseo employee

1. What is the name of this program?
2. When did this program begin?
3. How often does the program take place?
4. How old are the students in the program?
5. Are the students all from one class, or taken from multiple classes?
6. What is the goal of this program?
7. What are various teaching methods used by the program?

Questions for Michael Pacheco, USDA Biologist

1. What are the major bird attractants that you found at Tocumen International Airport?
2. What and where are the critical areas that need improvement?
3. What are some of the benefits of removing waste?
4. Are there any specific gates that do a great job of handling waste at the airport?
5. Which methods of bird deterrents do you feel the airport should be prioritizing?
6. Have you noticed any problems with the sound deterrents used at the airport?
7. Should public perception affect the way the airport handles the bird problem?
8. Are there any problems with the current waste removal route?
9. Will the community be able to handle the waste problem on their own, or do you feel that the community will need outside help?
10. Do you have any other ideas or suggestions for problem areas for our team to look into at the airport and in the community?

Questions for Isaac Escobar, Cabin Services Manager

1. How long have you been working for Copa?
2. What are your responsibilities?
3. Are you aware of the current bird strike problem at the airport?
4. What are your employees' responsibilities in regards to handling waste on planes?
5. How is the quality of the waste bags that are used by Copa?

# Appendix B

**SERVICIOS TECNOLÓGICOS DE INCINERACIÓN, S.A.**

SERVICIOS DE RECOLECCION DE DESECHOS INTERNACIONALES
EN EL AEROPUERTO INTERNACIONAL DE TOCUMEN
DEL 01 DE JUNIO AL 30 DE JUNIO 2016

| | | | KILOS | LIBRAS | TONELADAS |
|---|---|---|---|---|---|
| FECHA | N° DOCUMENTO | CANTIDAD BOLSAS | 14 APROX. | 2,20 | 2.000 |
| 01-jun-16 | 18229 | 410 | 5.740 | 12.628 | 6 |
| 01-jun-16 | 18230 | 287 | 4.018 | 8.840 | 4 |
| 02-jun-16 | 18231 | 345 | 4.830 | 10.626 | 5 |
| 02-jun-16 | 18232 | 280 | 3.920 | 8.624 | 4 |
| 03-jun-16 | 18233 | 322 | 4.508 | 9.918 | 5 |
| 03-jun-16 | 18234 | 304 | 4.256 | 9.363 | 5 |
| 04-jun-16 | 18235 | 409 | 5.726 | 12.597 | 6 |
| 04-jun-16 | 18236 | 274 | 3.836 | 8.439 | 4 |
| 05-jun-16 | 18237 | 396 | 5.544 | 12.197 | 6 |
| 05-jun-16 | 18238 | 392 | 5.488 | 12.074 | 6 |
| 06-jun-16 | 18239 | 309 | 4.326 | 9.517 | 5 |
| 06-jun-16 | 18240 | 354 | 4.956 | 10.903 | 5 |
| 07-jun-16 | 18241 | 358 | 5.012 | 11.026 | 6 |
| 07-jun-16 | 18242 | 289 | 4.046 | 8.901 | 4 |
| 08-jun-16 | 18243 | 386 | 5.404 | 11.889 | 6 |
| 08-jun-16 | 18244 | 256 | 3.584 | 7.885 | 4 |
| 09-jun-16 | 18245 | 448 | 6.272 | 13.798 | 7 |
| 09-jun-16 | 18246 | 271 | 3.794 | 8.347 | 4 |
| 10-jun-16 | 18247 | 330 | 4.620 | 10.164 | 5 |
| 10-jun-16 | 18248 | 263 | 3.682 | 8.100 | 4 |
| 11-jun-16 | 18249 | 345 | 4.830 | 10.626 | 5 |
| 11-jun-16 | 18250 | 425 | 5.950 | 13.090 | 7 |
| 12-jun-16 | 11651 | 311 | 4.354 | 9.579 | 5 |
| 12-jun-16 | 11652 | 326 | 4.564 | 10.041 | 5 |
| 13-jun-16 | 11653 | 405 | 5.670 | 12.474 | 6 |
| 13-jun-16 | 11654 | 308 | 4.312 | 9.486 | 5 |
| 14-jun-16 | 11655 | 396 | 5.544 | 12.197 | 6 |
| 14-jun-16 | 11656 | 284 | 3.976 | 8.747 | 4 |
| 15-jun-16 | 11657 | 401 | 5.614 | 12.351 | 6 |
| 15-jun-16 | 11658 | 320 | 4.480 | 9.856 | 5 |
| 16-jun-16 | 11659 | 431 | 6.034 | 13.275 | 7 |
| 16-jun-16 | 11660 | 279 | 3.906 | 8.593 | 4 |
| 17-jun-16 | 11661 | 454 | 6.356 | 13.983 | 7 |
| 17-jun-16 | 11662 | 318 | 4.452 | 9.794 | 5 |
| 18-jun-16 | 11663 | 413 | 5.782 | 12.720 | 6 |
| 18-jun-16 | 11664 | 270 | 3.780 | 8.316 | 4 |
| 19-jun-16 | 11665 | 380 | 5.320 | 11.704 | 6 |
| 19-jun-16 | 11666 | 428 | 5.992 | 13.182 | 7 |
| 20-jun-16 | 11667 | 329 | 4.606 | 10.133 | 5 |
| 20-jun-16 | 11668 | 412 | 5.768 | 12.690 | 6 |
| 21-jun-16 | 11669 | 438 | 6.132 | 13.490 | 7 |
| 21-jun-16 | 11670 | 337 | 4.718 | 10.380 | 5 |
| 22-jun-16 | 11671 | 442 | 6.188 | 13.614 | 7 |
| 22-jun-16 | 11672 | 262 | 3.668 | 8.070 | 4 |
| 23-jun-16 | 11673 | 426 | 5.964 | 13.121 | 7 |
| 23-jun-16 | 11674 | 338 | 4.732 | 10.410 | 5 |
| 24-jun-16 | 11675 | 410 | 5.740 | 12.628 | 6 |
| 24-jun-16 | 11676 | 304 | 4.256 | 9.363 | 5 |
| 25-jun-16 | 11677 | 284 | 3.976 | 8.747 | 4 |
| 25-jun-16 | 11678 | 410 | 5.740 | 12.628 | 6 |
| 26-jun-16 | 11679 | 282 | 3.948 | 8.686 | 4 |
| 26-jun-16 | 11680 | 306 | 4.284 | 9.425 | 5 |
| 27-jun-16 | 11681 | 427 | 5.978 | 13.152 | 7 |
| 27-jun-16 | 11682 | 330 | 4.620 | 10.164 | 5 |
| 28-jun-16 | 11683 | 446 | 6.244 | 13.737 | 7 |
| 28-jun-16 | 11684 | 268 | 3.752 | 8.254 | 4 |
| 28-jun-16 | 11685 | 345 | 4.830 | 10.626 | 5 |
| 29-jun-16 | 11686 | 358 | 5.012 | 11.026 | 6 |
| 29-jun-16 | 11687 | 193 | 2.702 | 5.944 | 3 |
| 29-jun-16 | 11688 | 167 | 2.338 | 5.144 | 3 |
| 30-jun-16 | 11689 | 483 | 6.762 | 14.876 | 7 |
| 30-jun-16 | 16690 | 258 | 3.612 | 7.946 | 4 |
| | | | 0 | 0 | 0 |
| | | 21.432 | 300.048 | 660.106 | 330 |

| | |
|---|---|
| CANTIDAD DE ACTAS Y SERVICIOS | 62 |

CONFECCIONADO POR: Elbe Perez

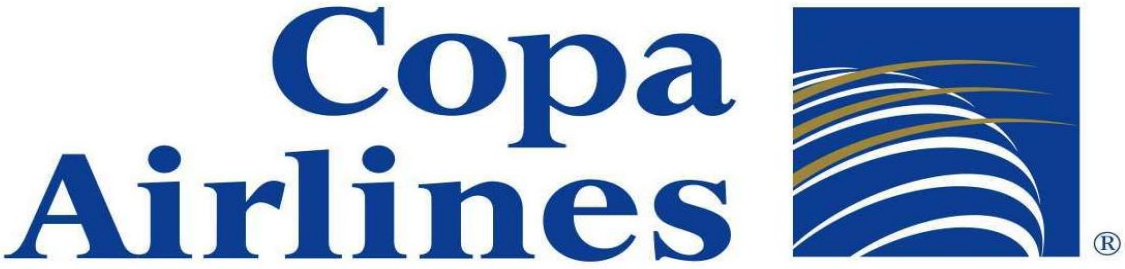
VERIFICADO POR:

APROBADO POR:

Isla Telfer, Camino al Muelle 16 Puerto de Cristóbal, Colón Rep. de Panamá
Tels (507) 395-0140 / (507) 395-0143 Apartado 0302-00762 Zona Libre de Colón
E-mail. service@stipanama.com www.stipanama.com

# Appendix C: Sponsor Description

**La Compañía Panameña de Aviación**




La Compañía Panameña de Aviación, or simply Copa Airlines, was established on June 21st, 1944 by a group of Panamanian investors with help from the now-defunct Pan-American World Airways (Copa Airlines Fleet Details and History, 2016). Airline operations then began on August 15th, 1947 (Copa Airlines, Our History). Copa Airlines currently navigates to seventy-two destinations in thirty countries (Figure 1).

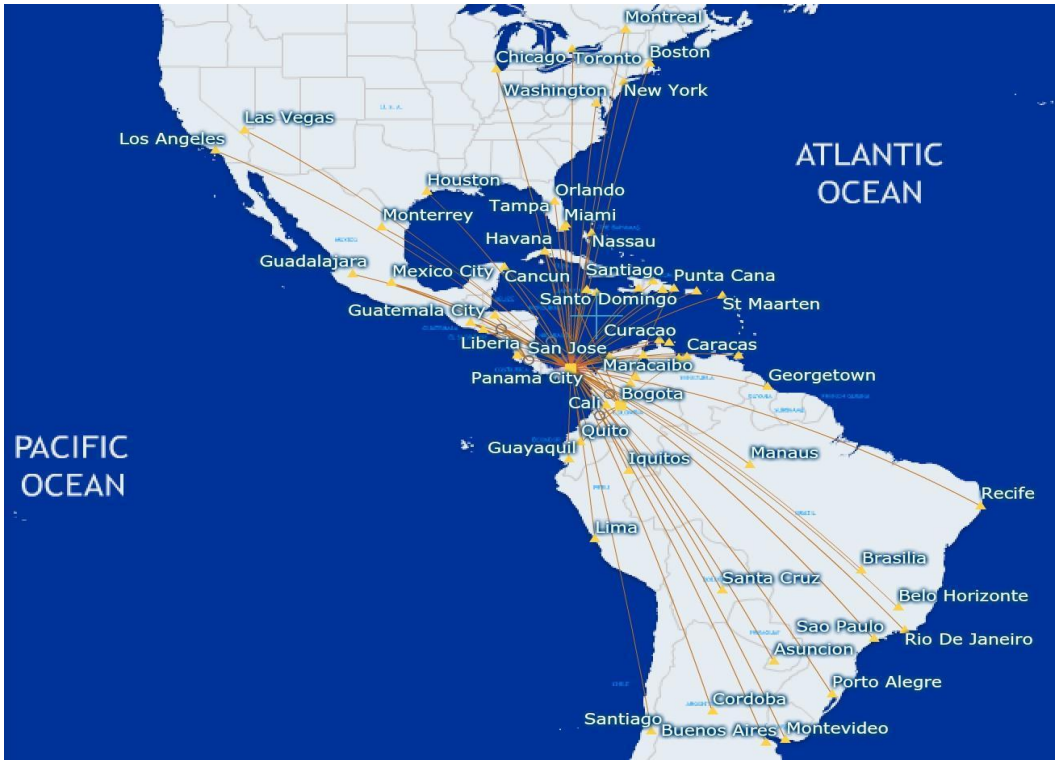



Figure 1: COPA Airlines Route Map (Source: Alternative Airlines)

They plan to continue increasing the scale of their operations and revenues by expanding their presence on new and existing routes. They claim that their ability to successfully implement this strategy will depend upon many factors, including the permanence of a suitable political, economic and regulatory environment within the Latin American countries in which they operate or intend to operate, and their ability to identify strategic local partners. (Copa Airlines, Our History)

After completely abandoning their domestic flights in the early 80s, they began to focus on international flights, navigating to North, South and Central America, as well as the Caribbean. Major expansions for Copa started during the early 90s, when they established frequent routes to Bogota (Colombia), Havana (Cuba), Lima (Peru), Caracas (Venezuela), Buenos Aires (Argentina) and Mexico City (Mexico). Today, these destinations compose half of their top twelve routes (Figure 2).

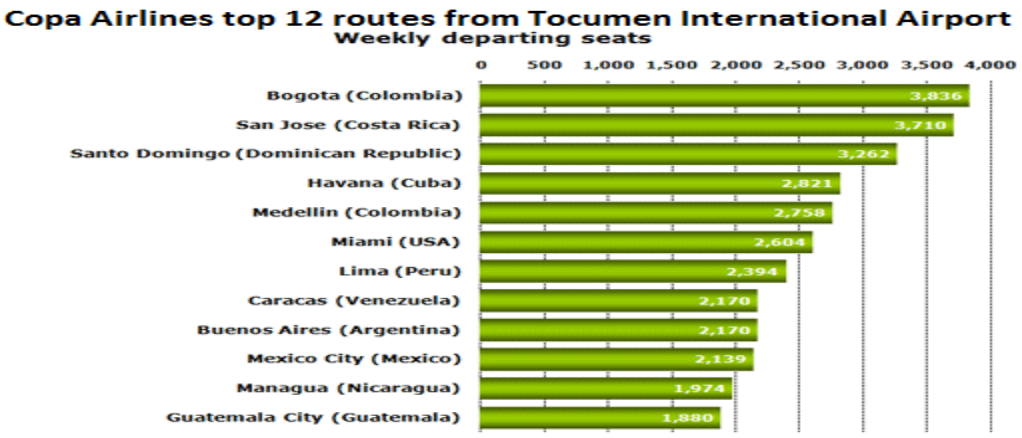



Figure 2: Copa Airlines top 12 routes from Tocumen International Airport (PTY). From (Airline Network News and Analysis)

Following on this success, in the early 2000s the airline began flying to New York City (New York), Orlando (Florida), Cancun (Mexico), and Sao Paolo (Brazil). In 2005, they became the majority owners of Colombian domestic air carrier AeroRepública, obtaining ninety percent of the company's shares. Copa then rebranded AeroRepública to Copa Airlines Colombia in 2010, increasing their destinations, and thus their revenues. They have since risen in prominence and have taken over the title of national airline of Panama that was previously vacant prior to its creation. (Copa Airlines, Our History)

Copa Airlines promotes a business strategy that is fundamental to the organization's operation: "Our goal is to continue to grow profitably and enhance our position as a leader in Latin American aviation by providing a combination of superior customer service, convenient schedules and competitive fares, while maintaining competitive costs" (Copa Airlines, Company Profile).

| | December 31, | | |
|---|---|---|---|
| | 2012 | 2011 | 2010 |
| Pilots | 944 | 877 | 791 |
| Flight attendants | 1,621 | 1,431 | 1,178 |
| Mechanics | 533 | 511 | 488 |
| Customer service agents, reservation agents, ramp and others | 3,401 | 3,023 | 2,859 |
| Management and clerical | 1,778 | 1,685 | 1,650 |
| | 8,277 | 7,527 | 6,966 |

Figure 3: Copa employee categorization (Copa Holdings, 2013)

As of 2012, Copa Airlines employs over 8,000 individuals and has steadily increased this number every year. The position breakdown of these employees can be seen in Figure 3. Roughly sixty-five percent of these employees are stationed in Panama, while the other thirty-five percent are distributed across the various foreign locations where Copa operates (Copa Holdings, 2013). Equally important to the success of Copa are the airplanes they have in use. Since 2015, a total of 102 aircraft are utilized by Copa, 65 of which are Boeing 737-800 airliners, a common passenger aircraft which is illustrated in Figure 4 (CAPA, 2015). As more destinations are added each year, the number of employees and airplanes increase.

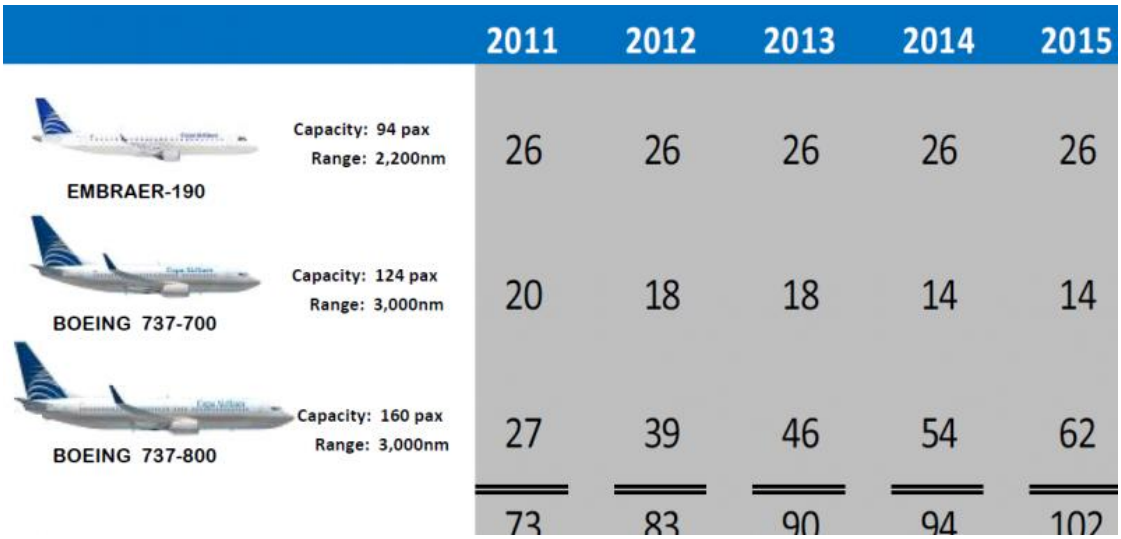



Figure 4: Copa Holdings fleet plan: year-end 2011 to year-end 2015 (CAPA, 2015)

Tocumen International Airport is greatly impacted by bird strikes. Copa Airlines occupies about eighty percent of the airport (Report: Panama 2014), meaning that every time bird striking occurs, there are great chances it is Copa aircraft that is damaged. Bird collisions threaten passenger safety and have the

potential to damage the aircraft. (Allan) Part of the mission of the airline is to provide high quality services to their customers. One manner to improve upon their current processes is through reduction of bird collisions with their aircraft. This reduction will then in turn reduce the cost of repairing damage from these occurrences as well as improve passenger satisfaction. Given the large number of aircraft that belong to the organization in this region, bird strike damage to company aircraft is a warranted concern. Recently, the airline has been concerned with one of the many factors that attract birds and wildlife in general to the communities surrounding the Tocumen International Airport: excessive waste within the communities.

Copa Airlines' CEO Pedro Heilbron recognizes his company's corporate responsibility to help the community. Three main focuses other than aviation for Copa Airlines are youth, education and environment (Heilbron). The organization has a program known as "Take Off" ("Despega") in which volunteers engage with in social and educational programs to over 25,000 youths in not only Panama, but also seventeen other countries. One program run by the contributors of Copa Airlines is the "Star Donor Program", which is the creation of a blood bank, primarily intended for children in emergencies. Another example of this program is the "Unforgettable Journey" program, in which Copa takes a group of impoverished youths on their first plane ride, and ending with a Christmas party and presents for each participant (Corporate Social Responsibility - Workforce). This program gives hope to children from these impoverished areas, as they will experience something they have never dreamed of. With regard to the environment, Copa Airlines follows the three Rs (Reduce, Recycle, and Reuse), and also wish to limit their $CO_2$ emissions, as well as the amount of noise created (Heilbron). Copa Airlines hope to fulfill the three R's and take care of the environment by staying up to date in new technology, as well as researching other methods that would help benefit the environment.

This focus on the environment illustrates why Copa Airlines would like to limit the bird strikes via reducing waste in the surrounding communities. Not only does excess waste cause problems for the environment, but it is also causes financial and safety harm to Copa Airlines, as this excess waste seems to be attracting the birds. As a result of Copa Airlines' pledge to help the environment, it is understandable that they are so willing to help with waste management, as they will be honoring their pledge to help the environment, as well as potentially reducing the number of bird strikes by reducing the waste in nearby neighborhoods.